VOLUME XXII

NUMBER FOUR

THE NATIONAL GEOGRAPHIC MAGAZINE

APRIL, 1911

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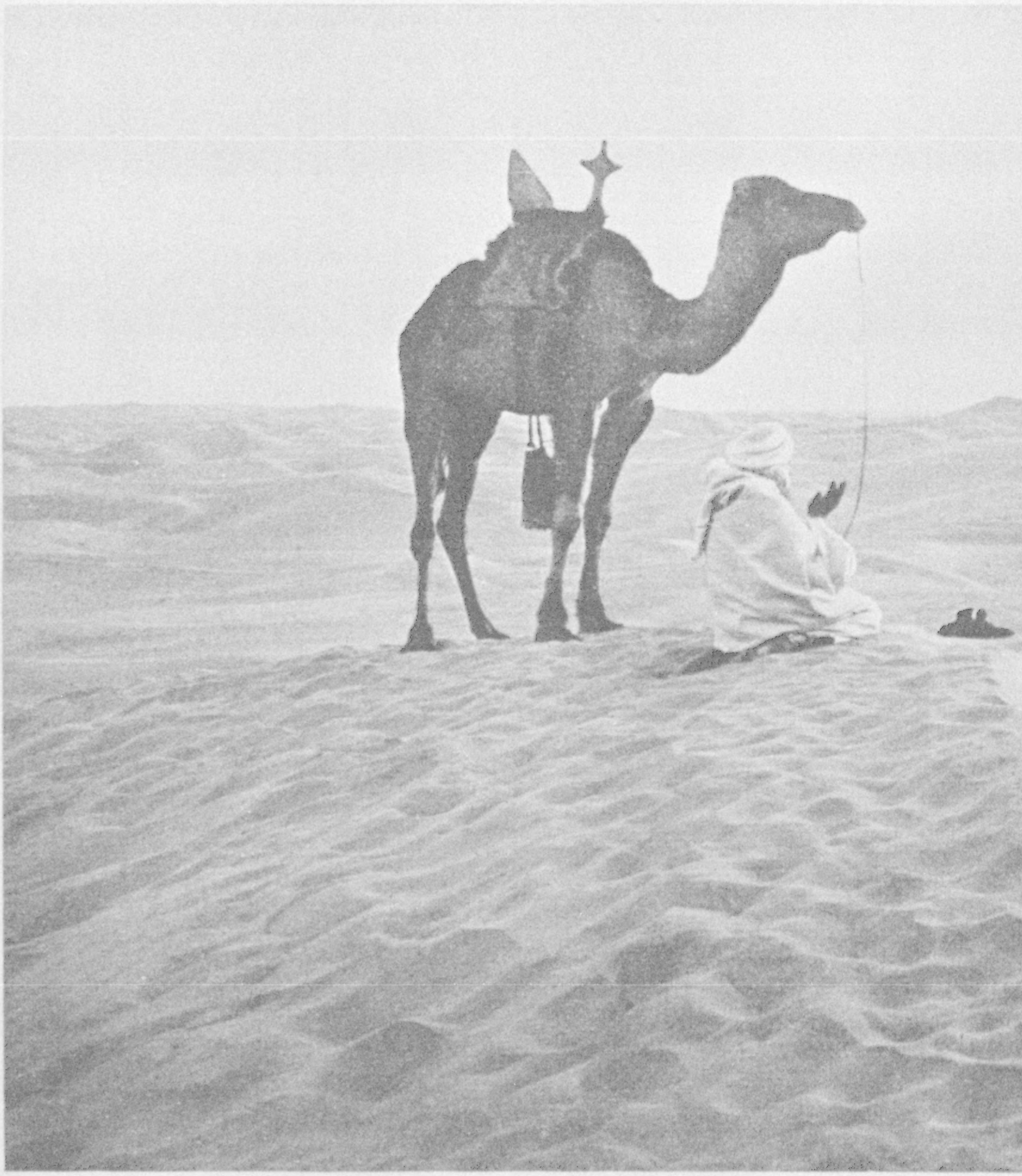

lement to the National Geographic Magazine (Washington, D. C.), April, 1911. Gilbert H. Grosvenor, Editor

THE HOUR OF PRAYER: IN THE SAHARA DESERT

Time is not here, nor days, nor months, nor years,
An everlasting NOW of solitude.

—Robert Southey.

XUM

THE HOUR OF PRAYER: IN THE SAHARA DESERT

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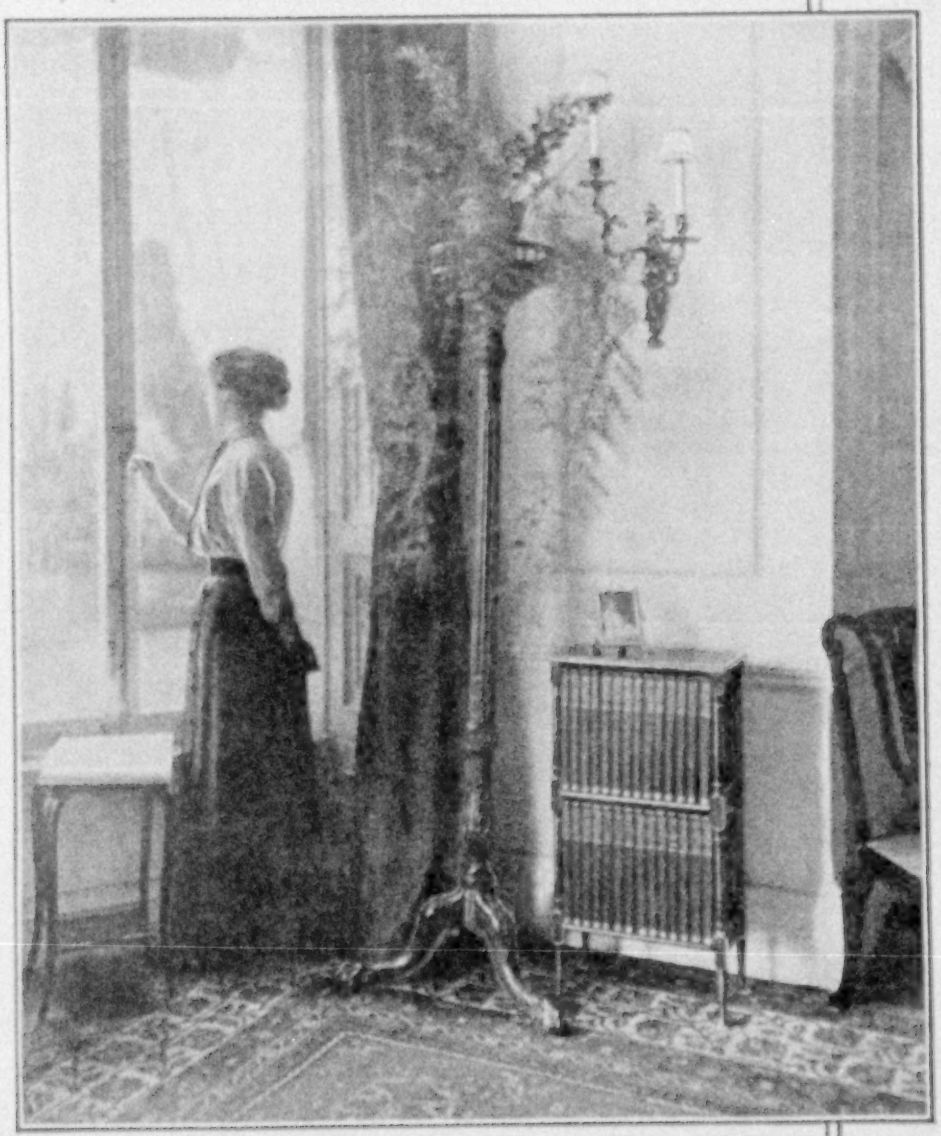

Interior view showing the India paper edition of The New Encyclopaedia Britannica (bound in full sheepskin), in the double-tier mahogany bookcase

P. T. O.

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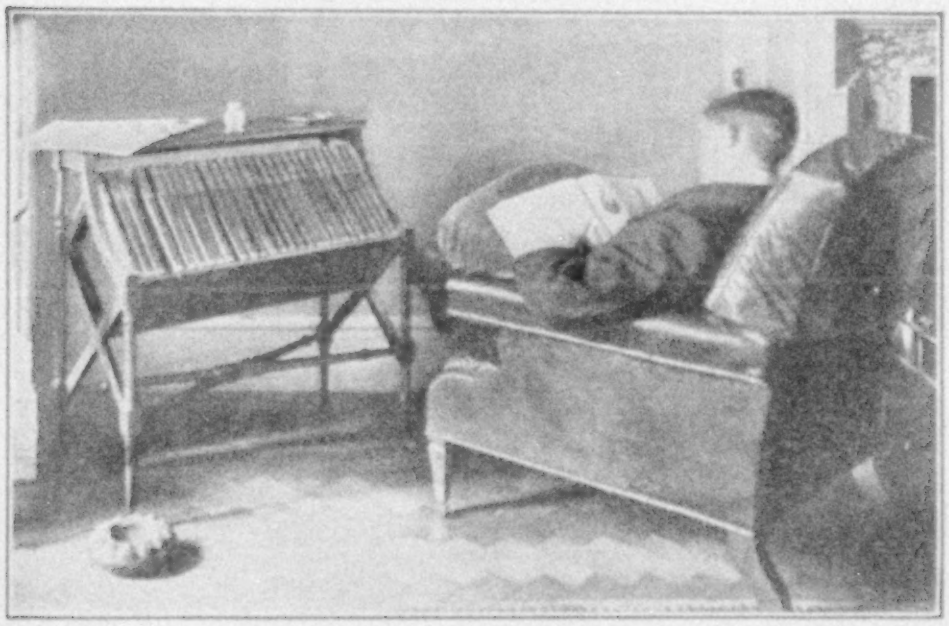

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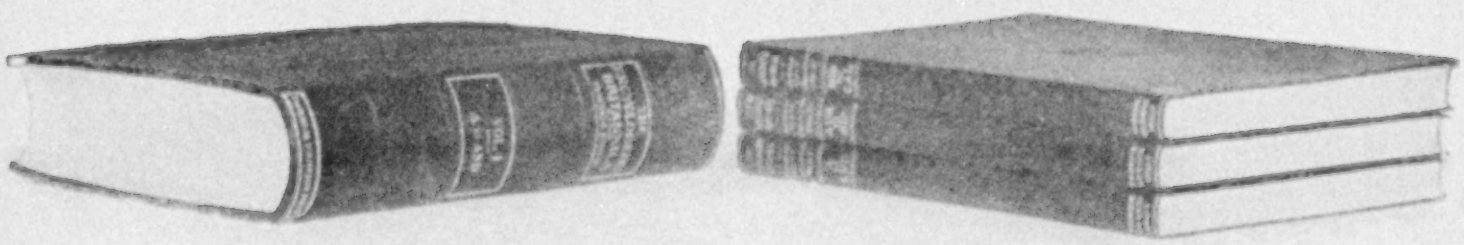

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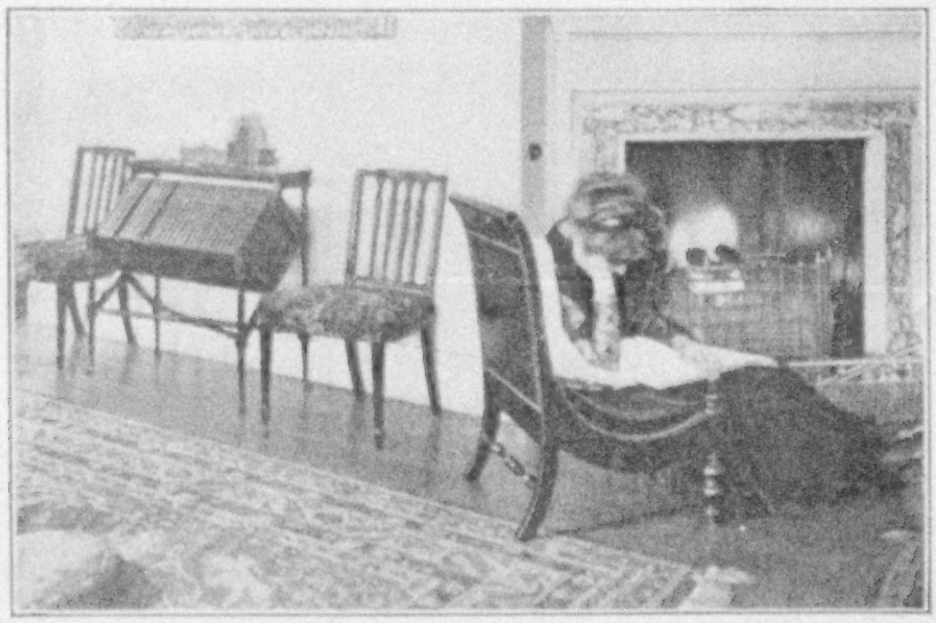

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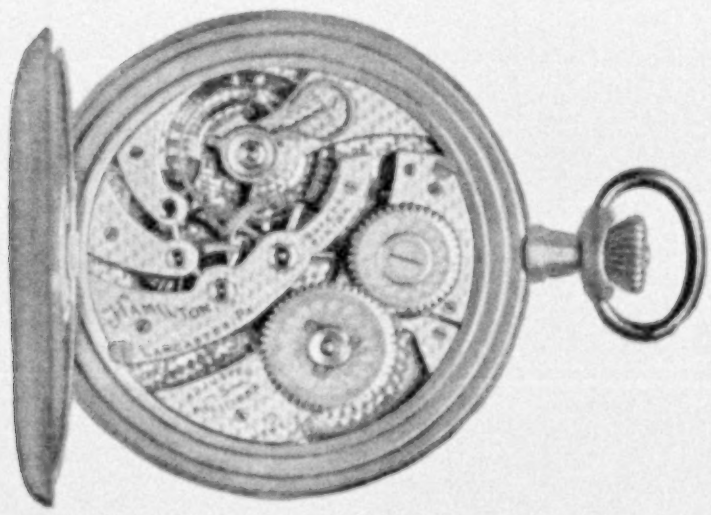

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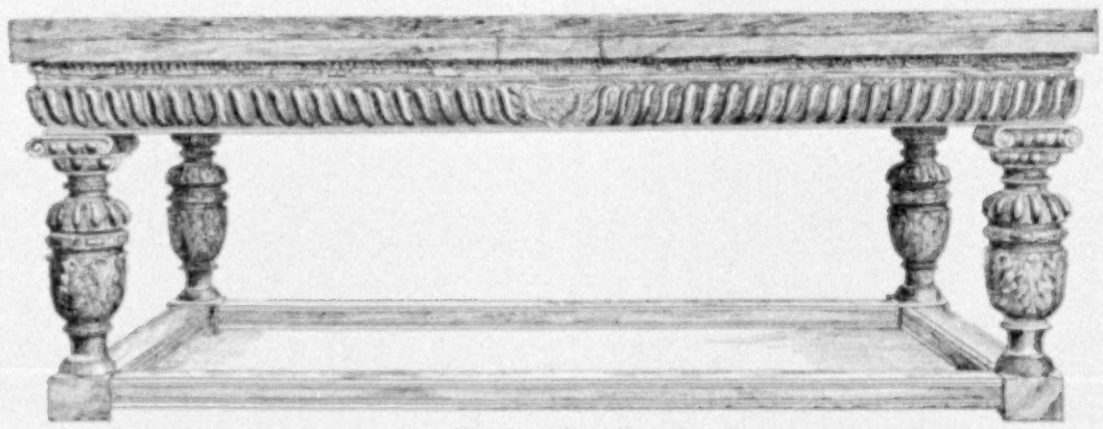

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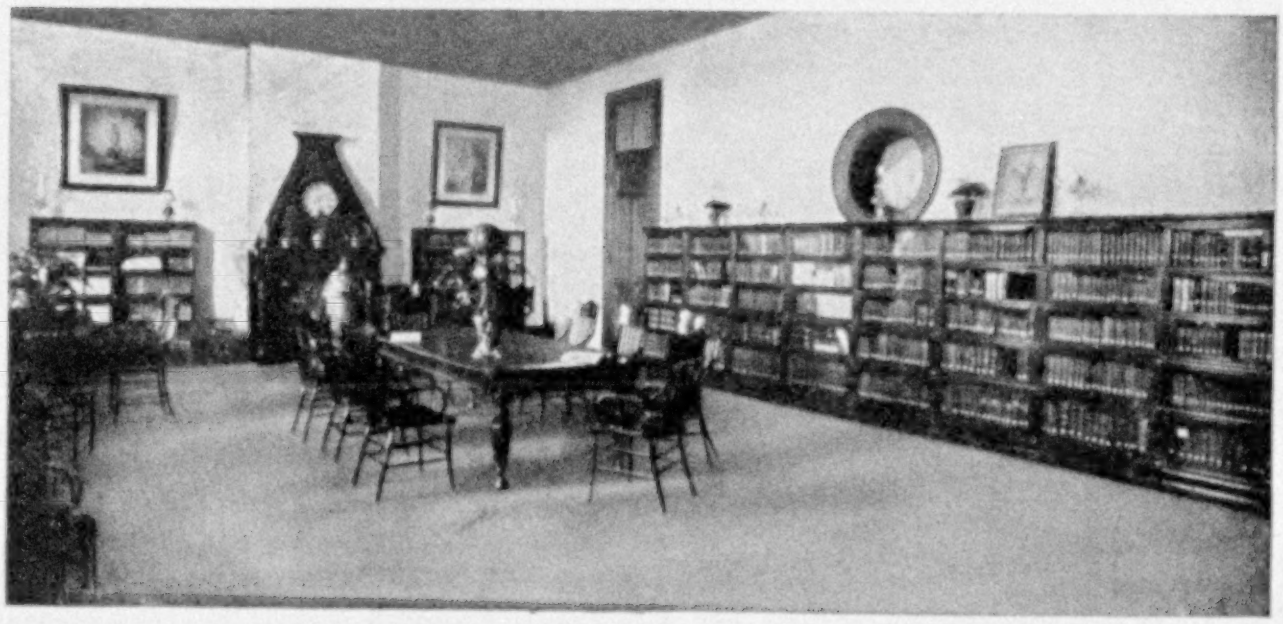

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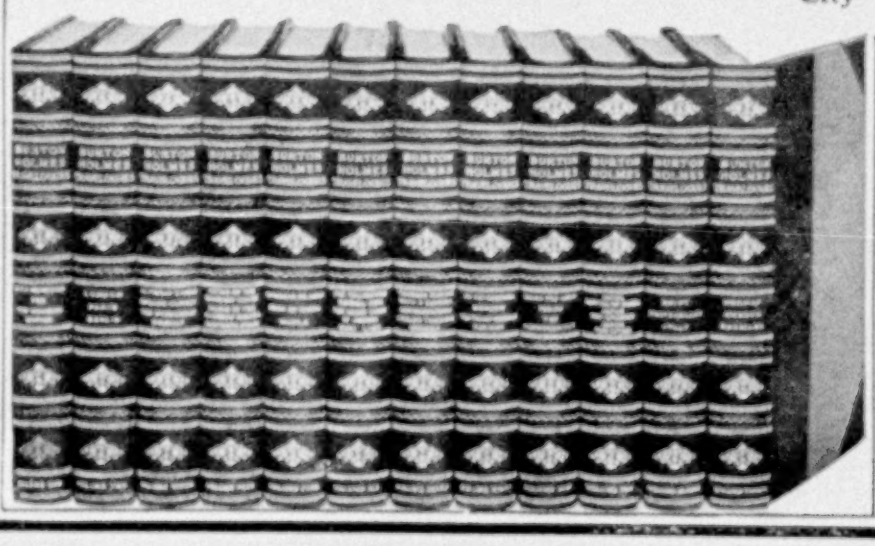

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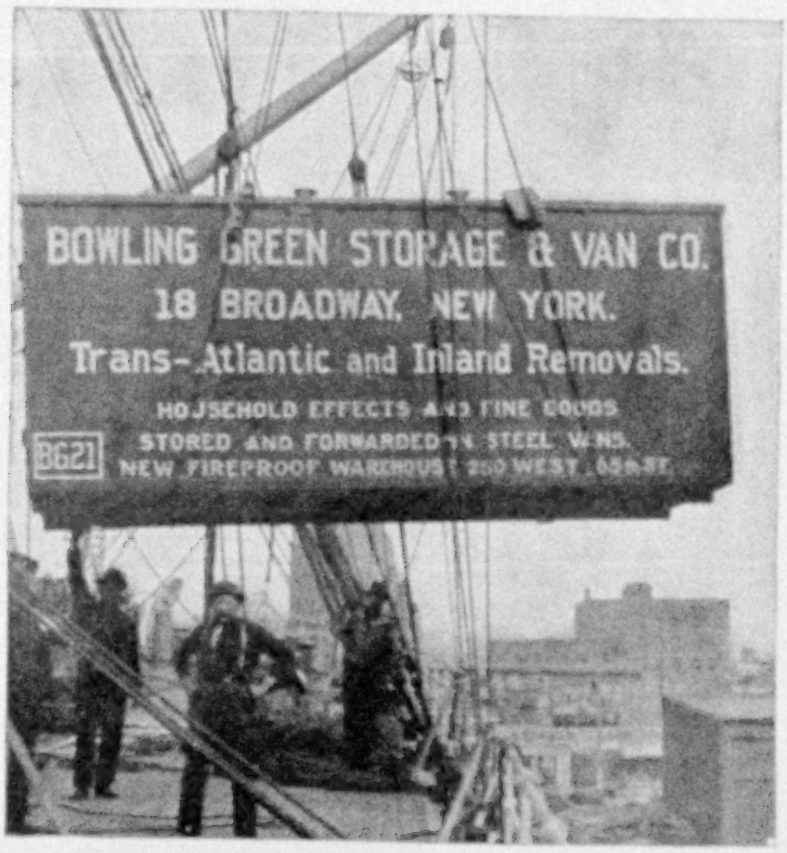

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VOL. XXII, No. 4 WASHINGTON APRIL, 1911

THE NATIONAL GEOGRAPHIC MAGAZINE

PESTS AND PARASITES

Why We Need a National Law to Prevent the Importation of Insect-Infested and Diseased Plants

By CHARLES LESTER MARLATT

OF THE BUREAU OF ENTOMOLOGY, U. S. DEPARTMENT OF AGRICULTURE

With Photographs from the U. S. Department of Agriculture

THE United States is the only great power without protection from the importation of insect-infested or diseased plant stock. Referring to European powers only, Austria-Hungary, France, Germany, Holland, Switzerland, and Turkey prohibit absolutely the entry from the United States of all nursery stock. Our apples and other fruits are admitted only when a most rigid examination shows them to be free from infestation. Most of the other European countries have very strict quarantine and inspection laws, and the same is true of the important English and other colonial possessions.

The United States thus becomes a sort of dumping ground for refuse stock. Diseased live-stock may be, and are, excluded by law, but diseased or insect-infested plants have no bar against their introduction.

A properly enforced quarantine inspection law in the past would have excluded many, if not most, of the foreign insect enemies which are now levying an enormous annual tax on the products of the farms and orchards and forests of this country.

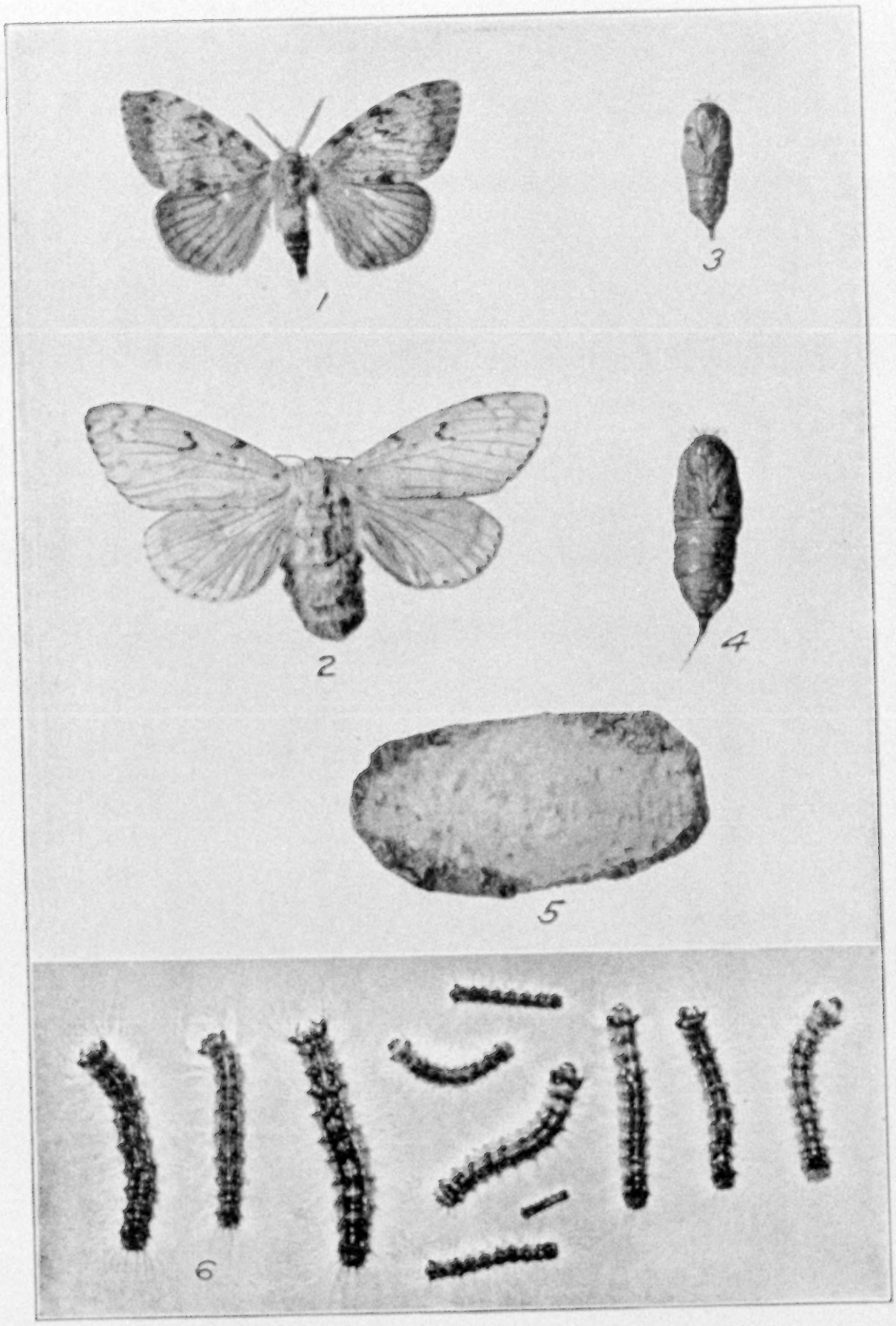
FOREIGN ORIGIN OF MANY OF OUR INSECT PESTS

Fully 50 per cent of the important injurious insect pests in this country are of foreign origin. Among these are the codling moth, the Hessian fly, the asparagus beetles, the hop-plant louse, the cabbage worm, the wheat-plant louse, oyster-shell bark louse, pea weevil, the Croton bug, the Angoumois grain moth, the horn fly of cattle, and in comparatively recent years have been introduced such important pests as the cotton-boll weevil, the San José scale, the gypsy and brown-tail moths into New England, the Argentine ant into New Orleans, and the alfalfa-leaf weevil into Utah.

While it is true that certain classes of injurious insect pests, such as the house fly and other household insects which may be similarly carried in ships' cargo or in the packing of merchandise, have been imported, and still will be, in spite of any quarantine law, however rigid, it

TREES THAT HAVE BEEN COMPLETELY STRIPPED OF LEAVES BY THE GYPSY MOTH

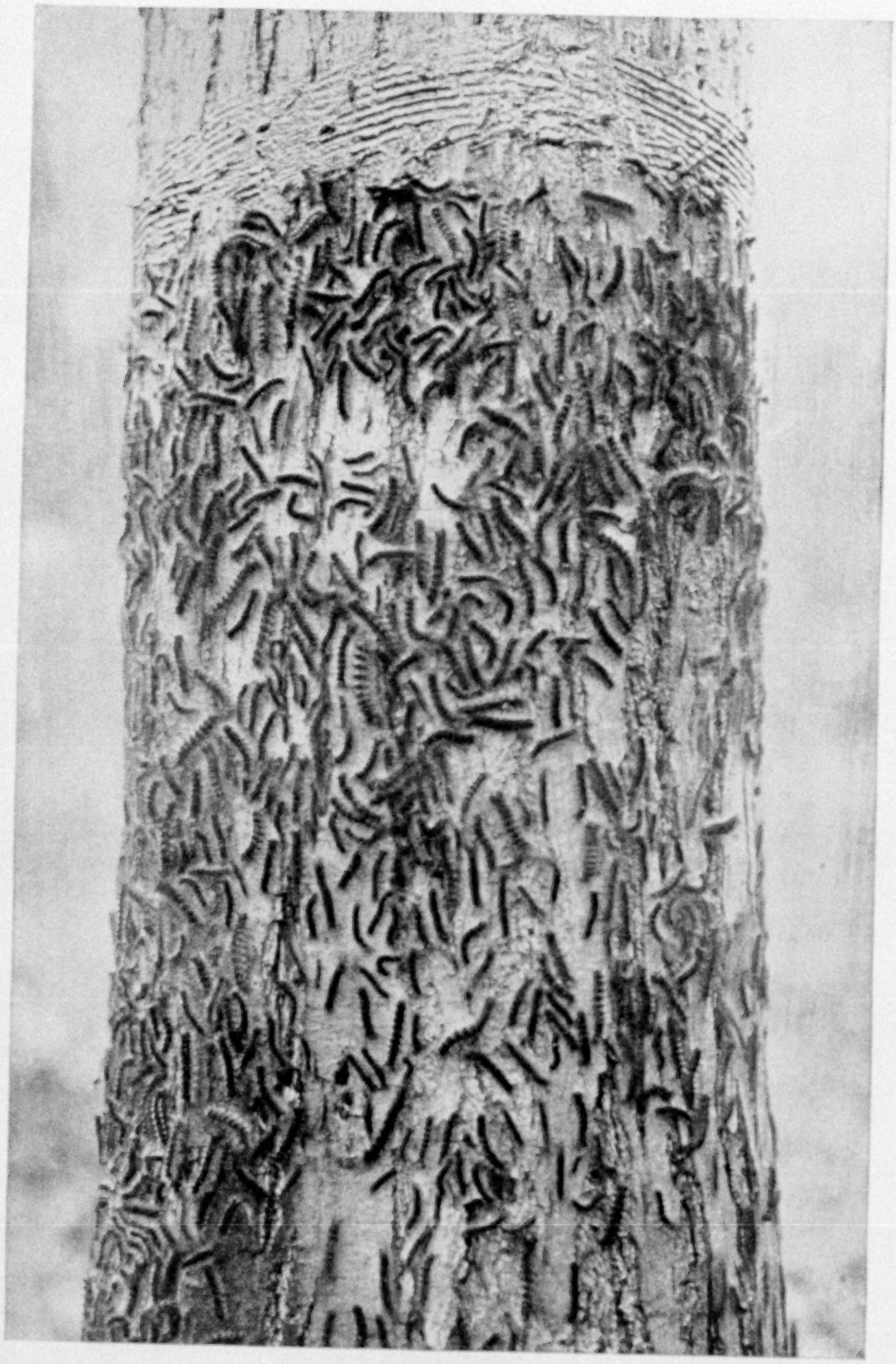
This picture of a woodland at Lexington, Massachusetts, was not taken in midwinter, but in July



THE GYPSY MOTH (*Porthetria dispar*)

Fig. 1. Male moth. Fig. 2. Female moth. Fig 3. Male pupa. Fig. 4. Female pupa. Fig. 5. Egg cluster. Fig. 6. Caterpillars; the largest are less than half grown.

The gypsy moth is one of the worst forest pests of Europe. It was accidentally introduced into Massachusetts 40 years ago, and has now spread to the adjacent States of Connecticut, Rhode Island, New Hampshire, and Maine. It has been recently brought into this country on imported stock and taken to such widely isolated points as Louisiana and Ohio. There is grave risk of its becoming distributed over the entire United States. It has already cost in New England, in mere efforts at control, a good many millions of dollars, and should it become widespread in the United States, damage from it would be beyond calculation. Every effort should be made to prevent a further introduction of this and other equally serious forest pests from Europe and Asia.



GYPSY-MOTH LARVÆ PREVENTED FROM ASCENDING THE TREE BY A BAND OF TANGLEFOOT

This is one of the efficient means of control, and especially for the protection of trees adjacent to infested territory

MASS OF GYPSY-MOTH LARVÆ WHICH HAVE COLLECTED UNDER A BAND OF BURLAP
After the larvæ are half grown they seek for shelter during the day, and will collect under burlap bands in enormous numbers, where they can be readily destroyed

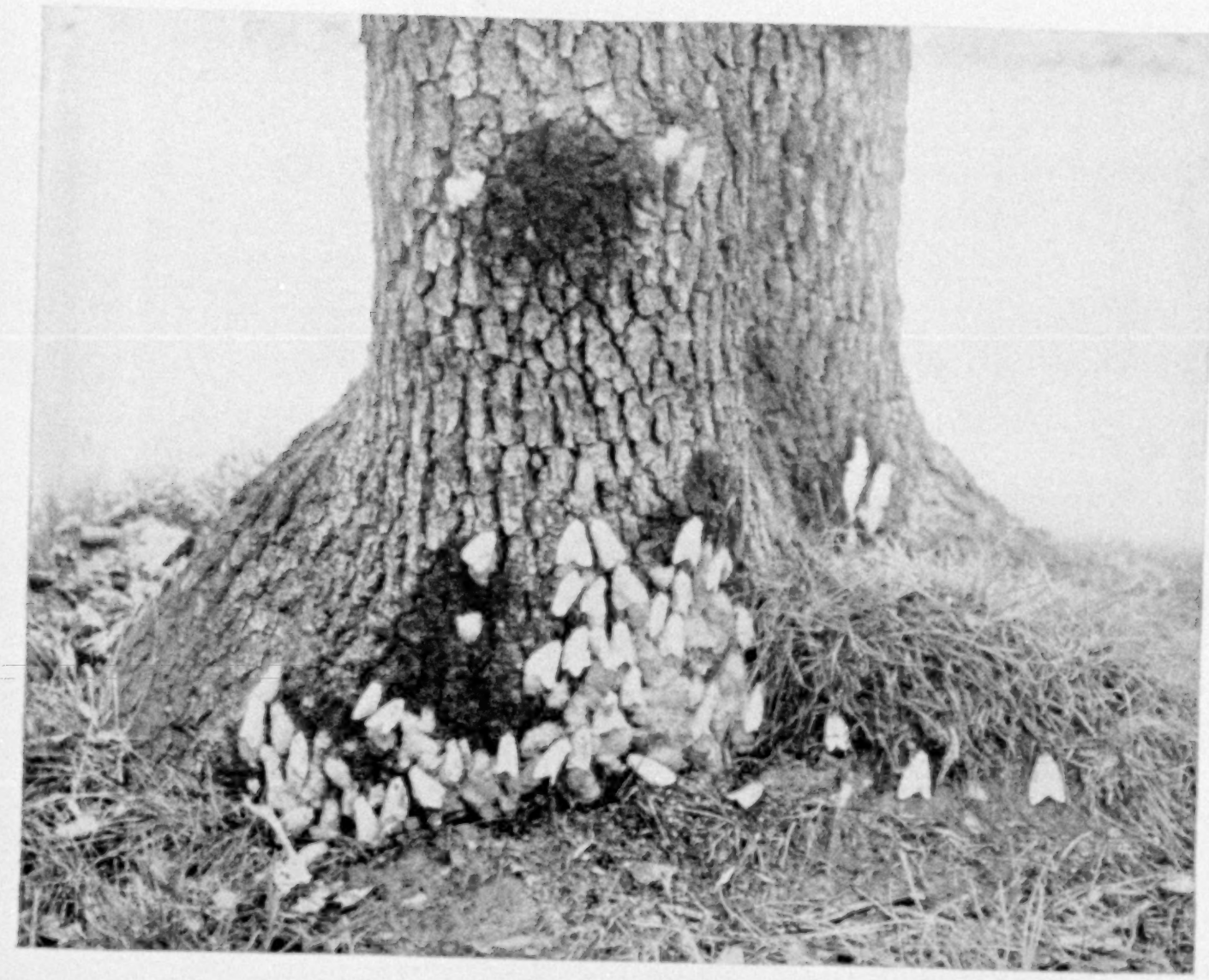
is essentially true that the great mass of the foreign insect enemies of orchards and forests have come in on nursery and ornamental stock, and might have been kept out, in large measure, if an efficient quarantine had been in operation.

THESE IMPORTED INSECTS COST US MANY MILLIONS OF DOLLARS YEARLY

The codling moth, or apple worm, occasions a loss, in cost of spraying trees and injury to fruit, of 16 million dollars a year; the San José scale, similarly in loss of product and cost of treatment of trees, 10 million dollars a year; the Hessian fly, the most important enemy of wheat, probably causes an annual loss of 50 million dollars, and in some years this loss has reached the enormous total of 100 million dollars. The cost to this country of the cotton-boll weevil, from the very conservative estimate of Mr. W. D. Hunter, amounts to about 25 million dollars a year. All these were imported.

The Argentine ant is destroying citrus orchards in Louisiana, and has spread to the orange groves of southern California; the alfalfa-leaf weevil, probably introduced on packing of nursery stock from Europe, has destroyed hundreds of fields of alfalfa in Utah, and is spreading to adjacent States.

The gypsy and brown-tail moths in Massachusetts and portions of other New England States are now costing those States, in expenditures merely in efforts at control, not counting damage at all, upward of a million dollars a year. In addition to this, the national government is appropriating $300,000 a year to aid in controlling these pests along the highways, and by this means check their more rapid distribution. In spite of these



FEMALE GYPSY MOTHS DEPOSITING EGG-MASSES AT THE FOOT OF AN OAK TREE

Each female deposits a mass containing from 400 to 500 eggs. The light oval patches between the moths are such egg-masses

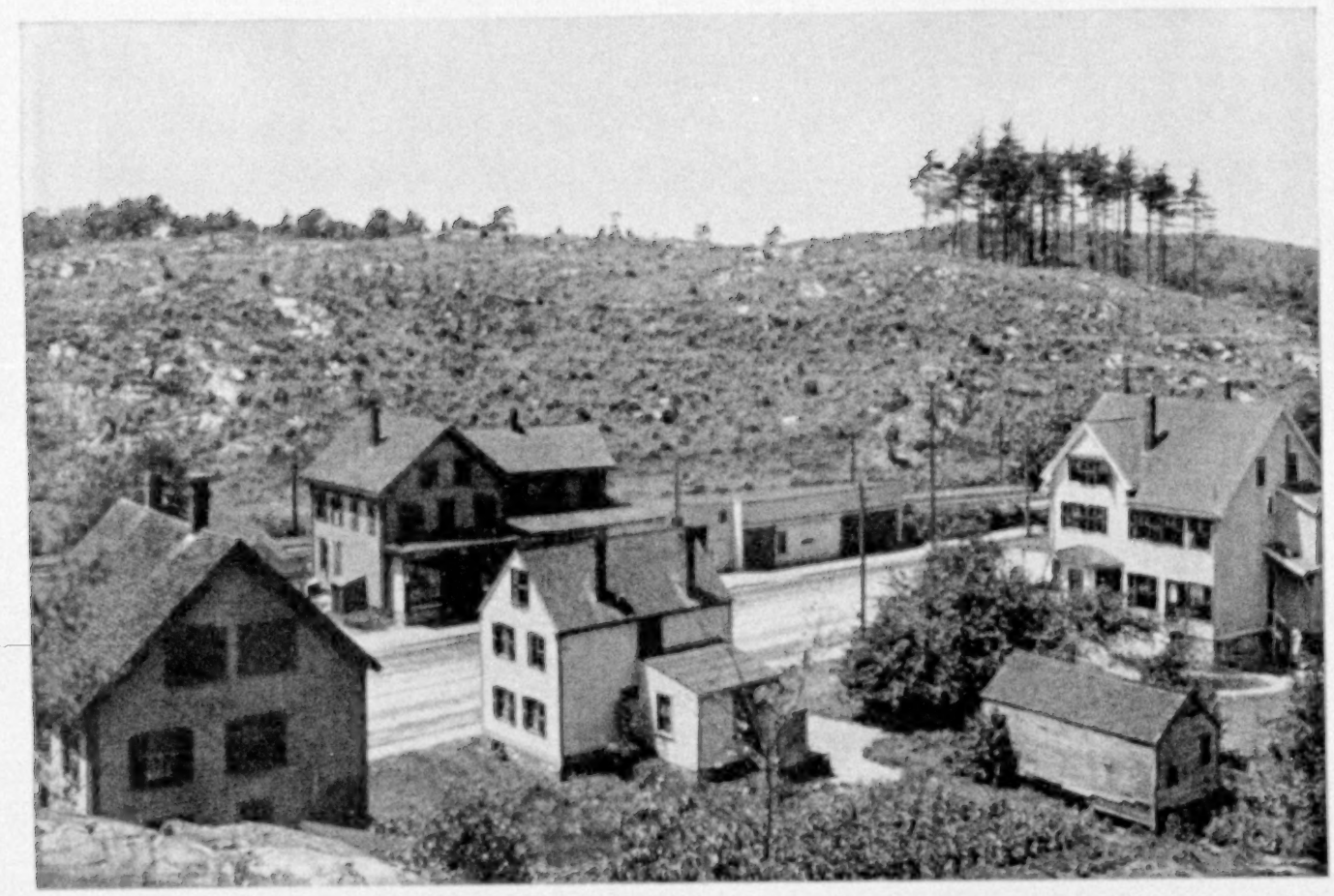
efforts and this enormous expenditure, these insects are slowly spreading, and great damage is done yearly to woodlands, private grounds, and orchards. The dissemination of these two pests over the whole United States, as is extremely likely under present conditions, would entail a like cost throughout the country—a tremendous and unnecessary charge on our fruit and forest interests.

Very careful estimates, based on crop reports and actual insect damage over a series of years, show that the loss due to insect pests of farm products, including fruits and live-stock, now reaches the almost inconceivable total of one billion dollars annually. The larger percentage of this loss is due to imported insect pests, and much of it undoubtedly would have been saved if this country had early enacted proper quarantine and inspection laws.

DANGER OF ADDITIONAL PESTS BEING IMPORTED

Great as is the number of foreign insect pests already imported and established in the United States, there remain many others with equal capacity for harm, which, fortunately, have not yet reached our shores or crossed our borders; or, at most, have infested only a limited part of our domain.

Our increasing business relations with China and other Oriental countries adds enormously to the risk of the importation



THE DEFORESTED HILL, WITH ITS UGLY FIELD OF STUMPS, SHOWN IN THIS PICTURE, WAS ONCE A BEAUTIFUL PINE GROVE

As the gypsy moth had stripped the trees of their foliage, they had to be cut down, because pine trees will not recover from a single stripping of their leaves. Elms, maples, and other deciduous forests will usually stand two or three defoliations.

of new pests. We know very little of the injurious insect pests of those countries, and particularly of China, but the importation of new stock in the last year or two, from China especially, has demonstrated the existence there of many pests which have not hitherto been known. The power of harm of these new pests is abundantly illustrated by the San José scale, which is one of the earliest of the Chinese insect pests to reach us, and undoubtedly came to this country with some ornamental nursery stock sent from north China.

Among the known foreign insect fruit pests which it is very desirable to keep out of this country are the Morellos fruit worm, which is an important enemy of citrus fruits in certain parts of Mexico; the olive-fruit worm, which occurs throughout the Mediterranean countries where the olive is grown; the mango-seed weevil, which has been found in imported mango seed during the present year; several fruit-scale pests known to occur in China, Japan, and other Oriental countries, which have records for harm quite as great as the San José scale; the gypsy and brown-tail moth to regions in this country where they do not now occur, and many other equally dangerous insect enemies of fruit trees, forest trees, and farm crops, known to occur in foreign countries.

In addition to the danger of importing these insect pests is the risk of bringing in new and dangerous plant diseases. Two illustrations of this danger only will be mentioned, but there are many others equally important. First may be noted a new disease of the potato, known as the "potato wart," which there is grave risk of establishing in this country. This disease, once in the soil, destroys the

PINE GROVE KILLED BY THE GYPSY MOTH (SEE PAGE 339)

PINE TREES THAT HAVE BEEN PROTECTED FROM THE ATTACKS OF THE GYPSY MOTH BY BURLAPPING AND OTHER MEANS

A HIGH-POWER SPRAYING APPARATUS TREATING A MASSACHUSETTS ROADSIDE WITH AN ARSENICAL WASH TO DESTROY GYPSY AND BROWN-TAIL MOTH CATERPILLARS

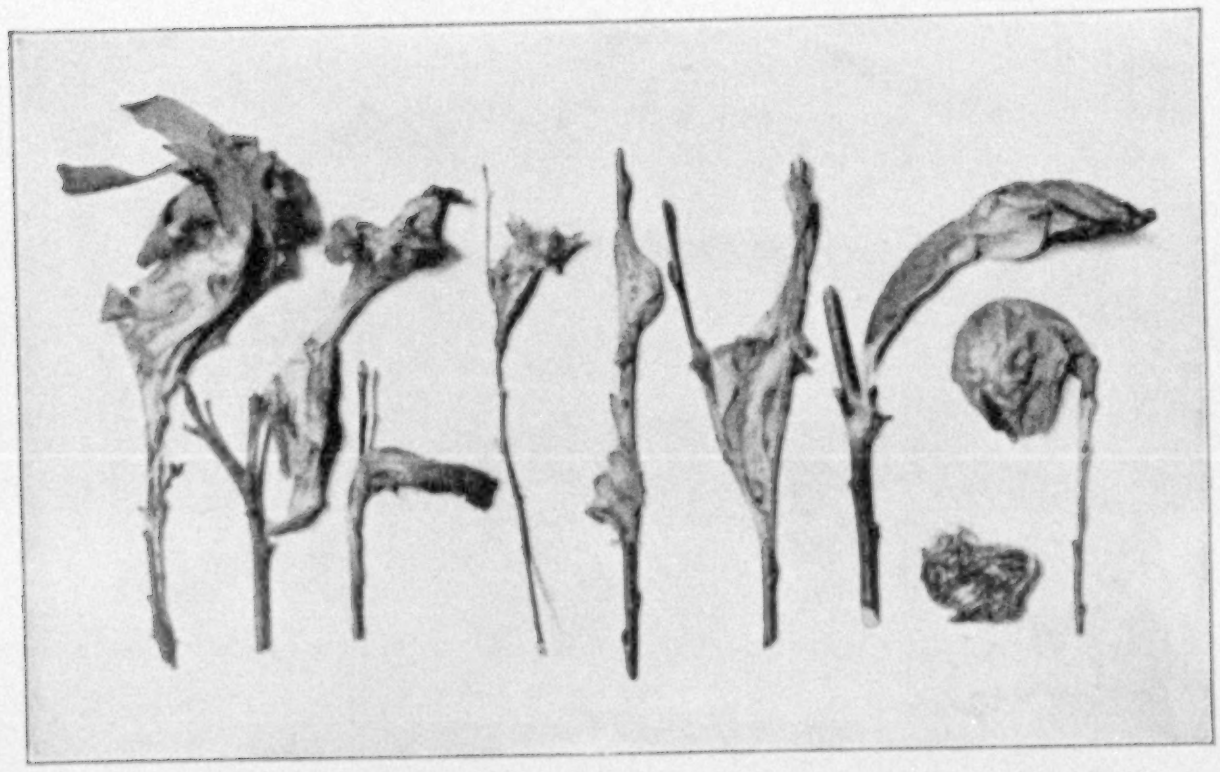
Note the water tower, by means of which the tops of the tallest trees can be reached with the poison spray. The National Government is spending $300,000 a year in such roadside work in an effort to prevent the rapid spread of the gypsy moth by carriage of caterpillars dropping from roadside trees on vehicles and automobiles, one of the principal means of spread.

potato tuber and prevents the culture of this staple. The disease was discovered in Hungary in 1886, and has since spread over portions of Europe and into England, where it is causing great alarm. It has also established itself in Newfoundland, and it is especially from this source that the danger to the United States comes. There is no known remedy for the disease, and its existence in the soil practically puts an end to potato culture. Its introduction into the United States would result in the loss of millions of dollars annually.

The other disease is the "white-pine blister-rust," which has caused enormous losses in Europe, particularly to nursery stock. This disease has, during the last

PHOTOGRAPH TAKEN IN AUGUST, 1910, BORDERING A ROADSIDE IN MASSACHUSETTS

The protected trees on the left border the road and have been sprayed; the trees to the right, further from the road, have not been treated, and have been practically stripped of their leaves by gypsy-moth caterpillars.

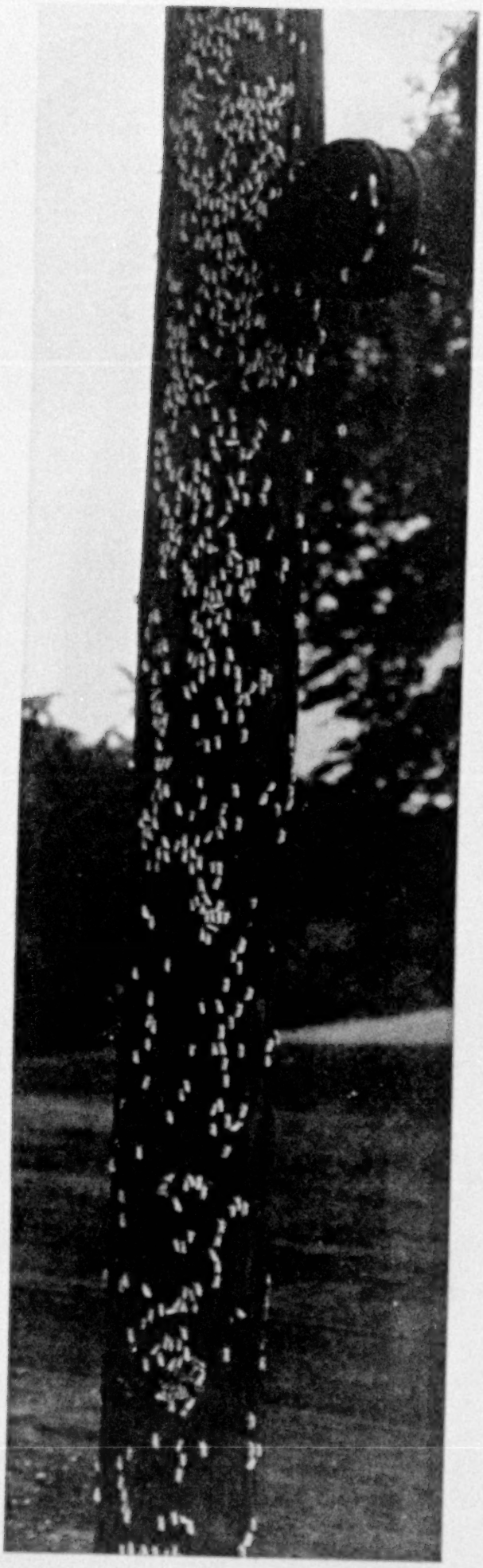


WINTER NESTS OF THE BROWN-TAIL MOTH, CONSISTING OF LEAVES AND WEB ATTACHED TO TWIGS

In these nests from 300 to 400 minute larvæ pass the winter

PILE OF 120,000 WEBS OF THE BROWN-TAIL MOTH GATHERED AND DESTROYED AT YORK, MAINE

York Harbor, Maine, has become thoroughly infested with the brown-tail moth. This illustration is a photograph of a pile containing 120,000 of the winter nests of the brown-tail gathered and destroyed in an effort to free the community from this pest. More than 40 million larvæ were contained in these nests. The brown-tail moth was imported by a Boston florist about 20 years ago on roses from Holland or France. It is a serious enemy of orchard, forest, and shade trees and ornamental shrubbery, and has long been recognized as one of the worst orchard pests of Europe. During the last three years it has been imported in enormous numbers on nursery stock from northern France, Holland, and Belgium, and carried to 22 States. There is no law to prevent such importations. The hairs on the caterpillars produce the brown-tail rash, which often affects residents of infested districts.



BROWN-TAIL MOTHS ON AN ELECTRIC-LIGHT POLE THE MORNING FOLLOWING A FLIGHT*

* These moths emerge early in July, are strong fliers, and have spread from the original point of infestation near Boston, northward and eastward, over much of New England. Fortunately the prevailing winds are to the northeast during this season, and their spread to the south and west has been comparatively limited.

year or two, been imported on nursery stock into a good many of our States and into the Province of Ontario, Canada. Earnest effort has been made to stamp it out at these points of introduction, and it is hoped that this work has been successful. If this disease becomes established in this country it will result in enormous losses in our pine forests.

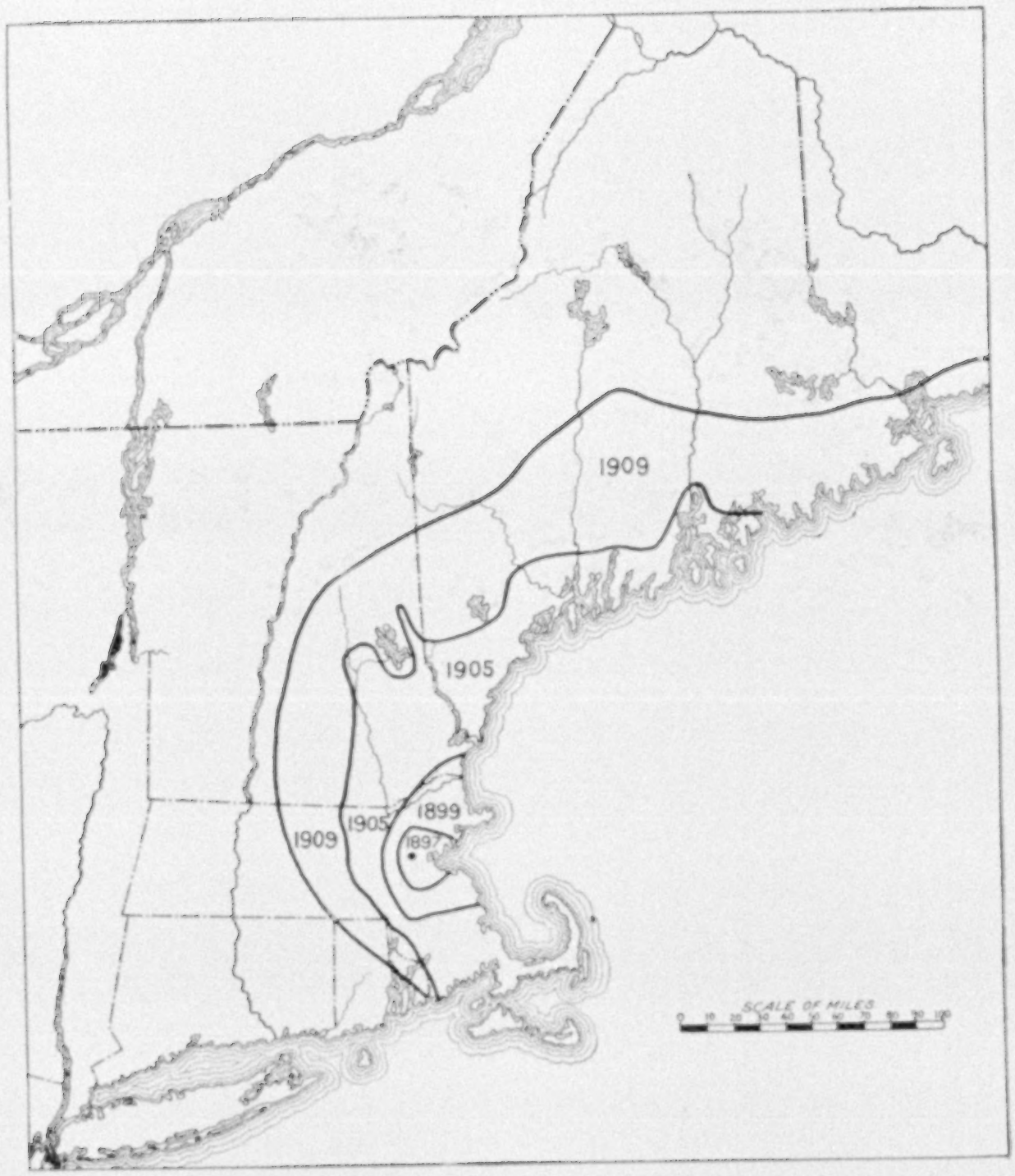
Both of these diseases are examples of dangers which can be prevented only by an absolute quarantining of the infested foreign districts, so far as importations therefrom to this country of these particular products are concerned. In other words, these diseases are often not discoverable by inspection, and cannot be destroyed by fumigation. The pine disease may be present in the pine for two or three years before giving any visible demonstration. The potato-tuber disease may be in imported potatoes and similarly escape detection.

EFFORTS TO SECURE LEGISLATION

The necessity for a national quarantine against foreign insect pests and plant diseases has long been recognized, and during the last 14 years, especially, a strong continued effort has been made to secure such legislation. This effort has been blocked very largely by a small body of importing nurserymen, who, careless of the consequences to the country at large, feared some slight check on freedom of their operations. The main body of nurserymen have interests identical with the fruit-growers and are in favor of protective legislation, and *The National Nurseryman*, the principal organ of the nursery trade of this country, has taken positive stand in support of such legislation.

The entire value of the imported nursery stock, as declared at customs, which is thus menacing the safety of this country is about $350,000 annually—scarcely more than the government is now appropriating to assist in the effort at the control of the gypsy moth alone in New England.

Some of this imported stock is of ornamentals neither new nor peculiar, and is merely brought in because of cheaper production abroad. A large percentage of it is seedling apple, pear,



MAP OF NEW ENGLAND, SHOWING AREAS INFESTED BY THE BROWN-TAIL MOTH

This map shows the progressive spread of the brown-tail moth. The prevailing winds during the summer flight in July have carried the insect eastward and northward much faster than southward and westward. This is the insect which is now being introduced on imported nursery stock, and if it gains a foothold in a few interior points its means of rapid spread would enable it to quickly infest the whole country.

cherry, plum, and quince stock. It is held by importing nurserymen that particularly the cherry, plum, and quince stock is better grown abroad than at home. Nevertheless, until recently all such stock was home-grown, and probably the bulk of the apple-seedling stock is still home-grown. Admitting the necessity of the importation of some seedling stock, it is all the more desirable to have means to thoroughly inspect, and, if necessary, quarantine such stock.

The first concerted effort to obtain a national quarantine and inspection law

A HEDGE-ROW IN BELGIUM HEAVILY INFESTED WITH WINTER NESTS OF THE BROWN-TAIL MOTH, THE SMALL BLACK DOTS SEEN ON THE BRANCHES

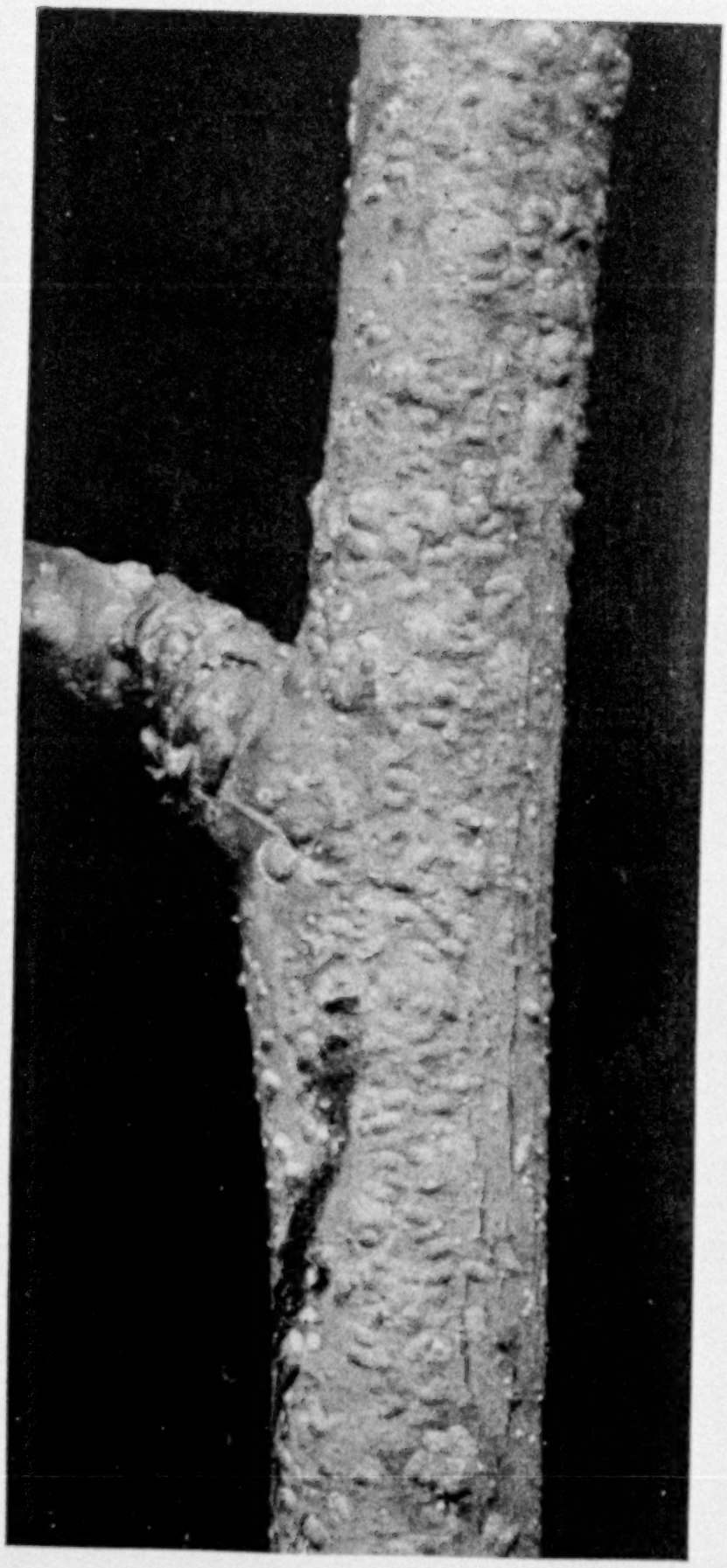
This is a common condition of hedge rows and trees in Belgium. This photograph was taken within a few miles of the Holland border and within easy flight of the moths to certain large Dutch nurseries, which send immense quantities of stock to this country.

WINTER (1910) NESTS OF THE BROWN-TAIL MOTH IN AN INFESTED DISTRICT OF MASSACHUSETTS

These are easily recognizable objects and must be pruned off during winter and burned

THE EARLY STAGES OF THE SAN JOSÉ SCALE AT WORK IN A PEACH ORCHARD

Trees in full fruit dying. Peach, apple, and other trees are very quickly killed by this scale insect. The San José scale is probably the worst orchard pest that has ever come to America. It was evidently brought with ornamental stock from north China, its native home. It has already caused a loss of more than 50 million dollars, and more than 5 million dollars a year are now being spent for spraying trees to control it. This is an annual tax which does not include the damage to the trees and fruit, much exceeding the cost of spraying.



THE SAN JOSÉ SCALE AS IT APPEARS ON THE BARK

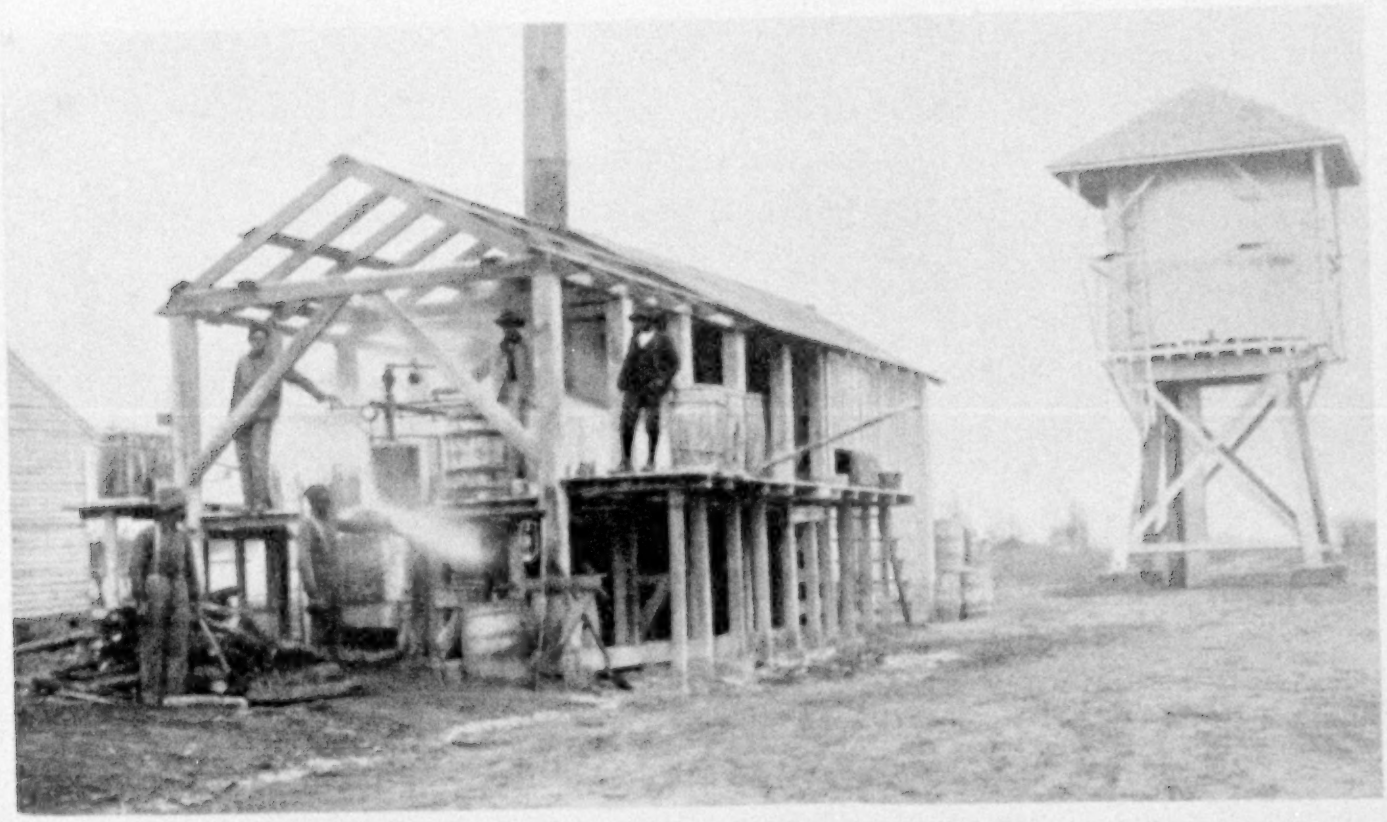
The small white dots are the young scale insects, and the larger shell-like objects are the full-grown scales. The insect lies beneath this shell-like covering, and is thus protected from parasitic enemies and from any except strong-killing washes.

was due to the introduction in the East on nursery stock of the San José scale in the early 90's. The failure to reach an agreement as to suitable legislation among the nurserymen, fruit-growers, and entomologists prevented anything coming from this effort, although several bills were introduced in Congress from time to time. In the meanwhile the San José scale became so widely distributed by transportation on infested nursery stock that quarantine against this insect was no longer practicable, and the country is now being taxed, and probably will be for all time, many millions of dollars annually in consequence of the absence of any law under which strong hold could have been taken of this danger at the outset.

CRIMINAL CARELESSNESS

The present effort to secure legislation resulted from the discovery two years ago of the introduction of enormous quantities of brown-tail moth nests, full of hibernating larvæ, on seedling fruit stock, chiefly from northern France. With these were occasional egg-masses of the gypsy moth. During the years 1909 and 1910 such infested stock was sent to no less than 22 different States, covering the country from the Atlantic seaboard to the Rocky Mountains. During the first of these years no less than 7,000 winter nests of the brown-tail moth, containing approximately 2,800,000 larvæ, were found in shipments to New York State alone—seed material enough to infest the whole United States within a few years.

So far as possible, this stock sent to the different States has been examined and the brown-tail moth nests removed and de-

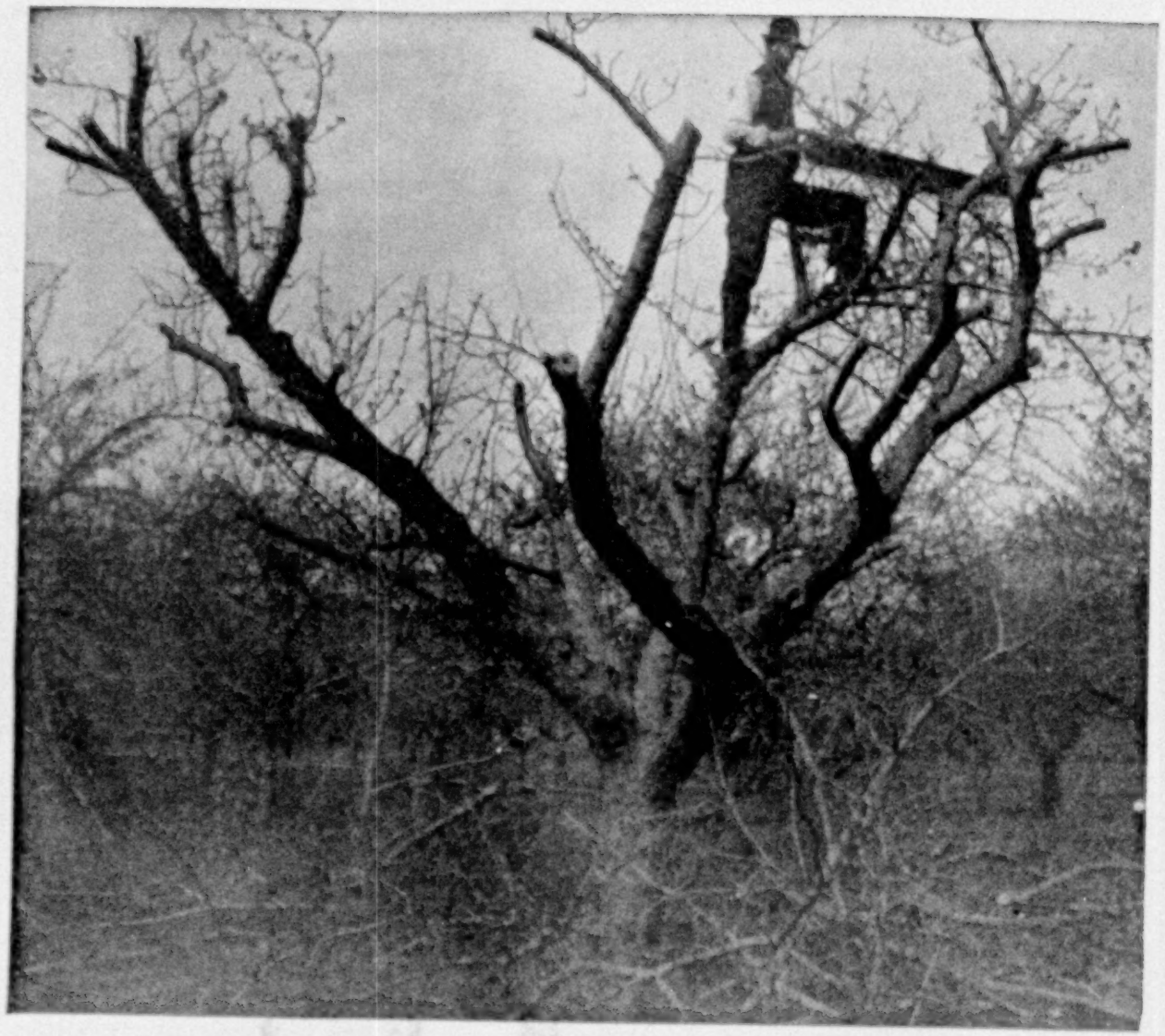


A PLANT FOR PREPARING LIME-SULPHUR WASH

This wash is prepared by cooking a lime and sulphur mixture with steam. The mixture is applied to trees in late winter, and is the best remedy so far found for the San José scale. All the large commercial orchards have their own plants for preparing this wash, which must be applied yearly to save the trees and fruit crop.

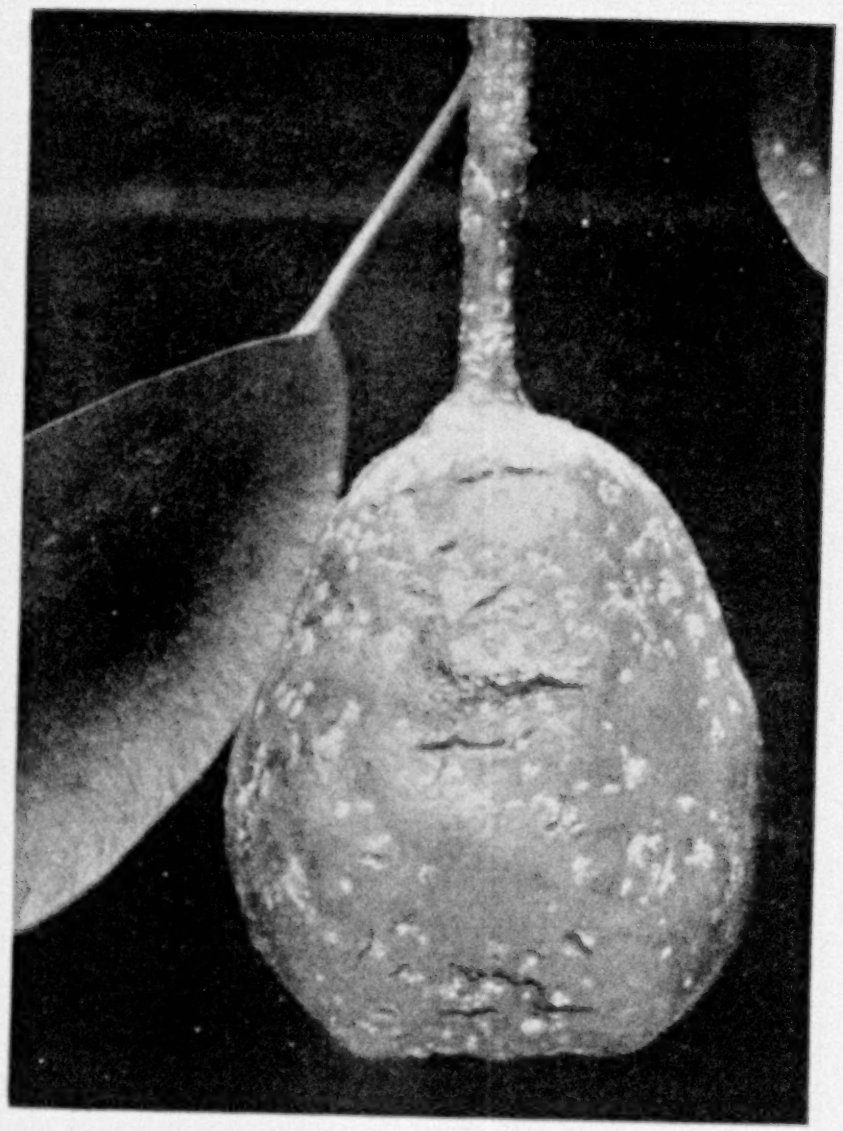
A SPRAYING APPARATUS FOR APPLYING THE LIME-SULPHUR WASH IN ORCHARDS

This is a winter treatment, and is the best-known means of controlling the San José scale. More than 5 million dollars a year are spent by fruit-growers in spraying orchards in this way. In addition to this cost is the actual loss from the San José scale itself, which very much exceeds the cost of the spray application in orchards not sprayed or imperfectly treated. A proper inspection and quarantine law would have prevented this enormous yearly loss.



CUTTING BACK AN APPLE TREE INFESTED WITH THE SAN JOSÉ SCALE PRELIMINARY TO SPRAYING

The cost of this work is very heavy in labor, and it means a loss of fruit for several years, as well as serious permanent injury to the tree



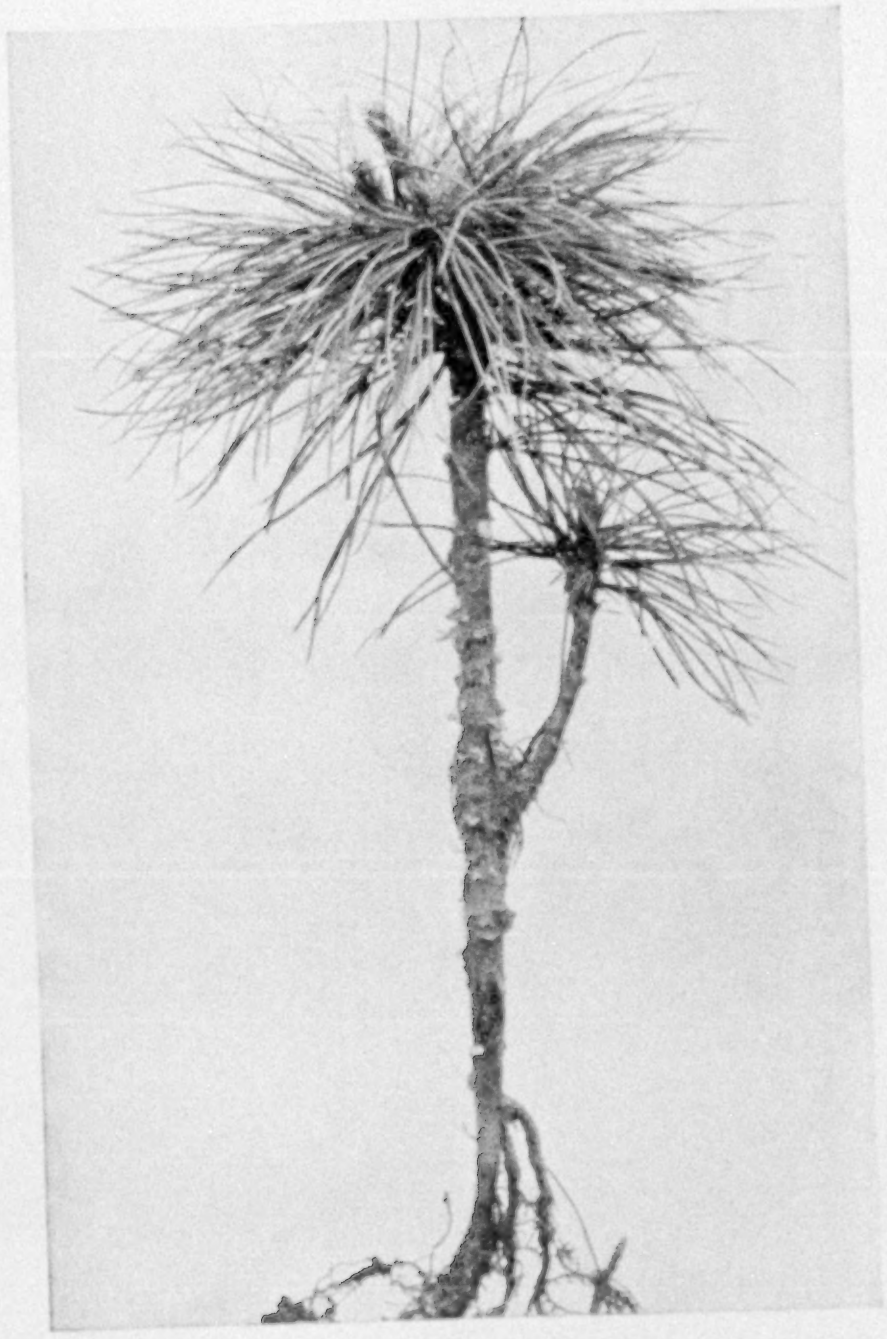
A PEAR INFESTED WITH THE SAN JOSÉ SCALE

The scale insect in sucking juices from the fruit or bark poisons the plant and causes a deformation of the fruit, as well as the killing of leaves and twigs, and ultimately the tree itself.

stroyed by State authorities; or, where these were not available, by the agents of the Bureau of Entomology of the United States Department of Agriculture. It is by no means certain, however, that all of the infested shipments have been located and freed.

It is scarcely necessary to comment on the tremendous danger to this country from the careless introduction and wide distribution of the brown-tail and gypsy moths with nursery stock. The cost of these insects in the New England States has already been referred to. The tax from these pests, should they gain a foothold throughout the country, is almost beyond estimate.

In addition to their great destructiveness to orchards and forests, the establishment of the brown-tail or gypsy moths in any suburban residential district means an enormous depreciation in property values, as is well illustrated about the city of Boston, and very notably lessens the attractiveness of coast or mountain summer-resort districts. The north-shore towns of Massachusetts and lower Maine resorts have already felt this influence, and for such regions as the Catskills or Adirondacks the establishment of these pests would mean an end of their more pleasing features. Control over such extended forested mountains would be a practical impossibility, and few would care to live amongst defoliated and caterpillar-infested trees, with the additional risk of dangerous and lasting poisoning from contact with the hairs or molted skins of the brown-tail moth.



A SEEDLING PINE

The white-pine blister rust, one of the most dangerous diseases of pine trees in Europe, is probably not yet established in America. Seedling pines affected by this disease are now being imported in enormous numbers. It was necessary to burn an entire shipment of 25,000 trees recently received in New York State. In its early stages this disease shows no outward sign, and hence can be excluded from this country only by prohibiting the importation of seedling pines from districts in Europe known to be infested. Its establishment in America would mean a tremendous loss to pine forests. The illustration is one of the diseased pine seedlings. The excrescences on the stem are the postules of the fungus.

THE BROWN-TAIL RASH

In addition to the great monetary loss, the brown-tail moth exercises a very deleterious effect on health. The hairs which cover the caterpillars of this moth are strongly nettling, and not only are they so from accidental contact with a caterpillar which may fall on clothes,

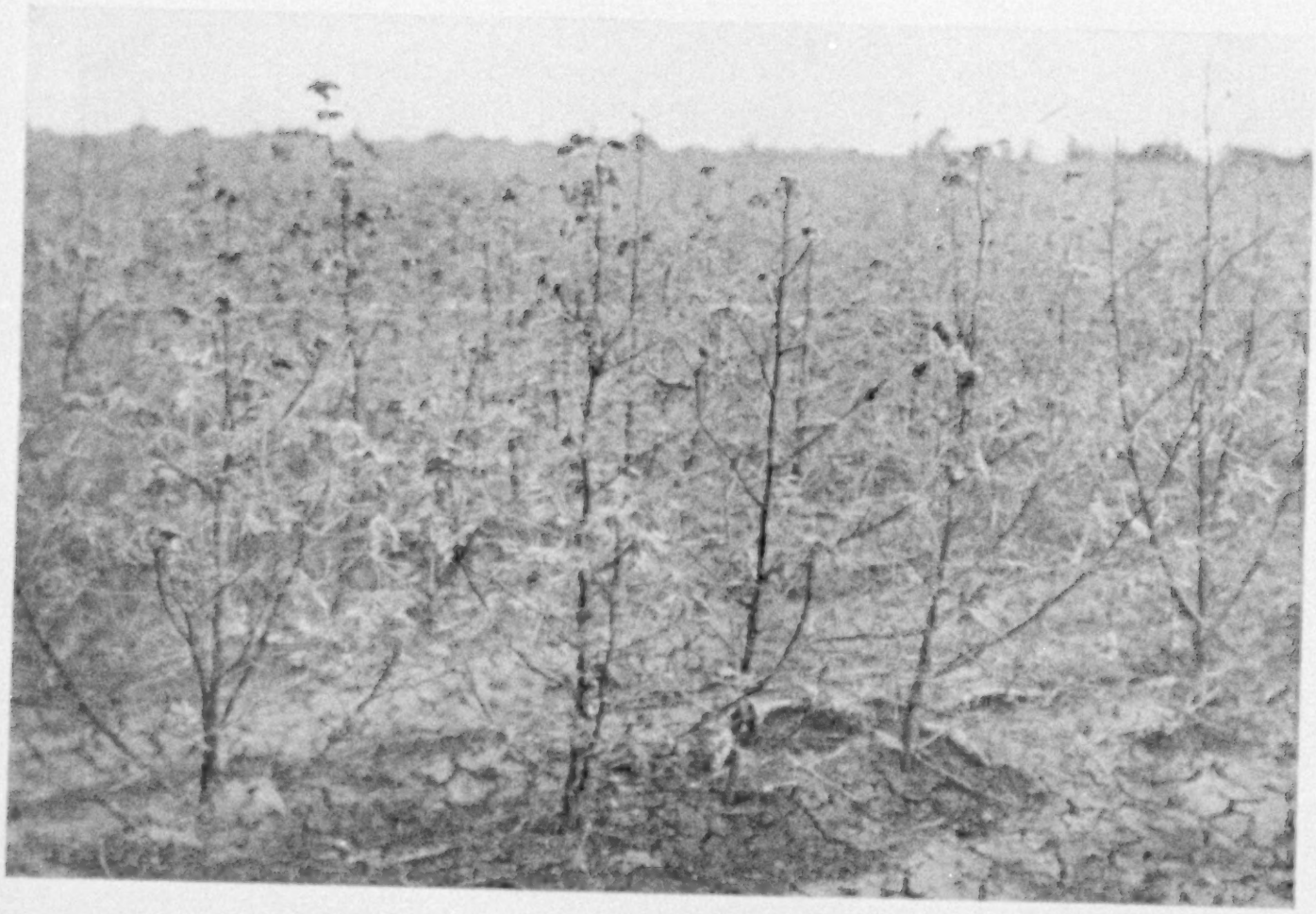


ILLUSTRATION SHOWING A COTTON FIELD PLANTED LATE AND YIELDING NOTHING, BECAUSE OF THE RAVAGES OF THE BOLL WEEVIL

The cotton-boll weevil, an immigrant from Mexico, first invaded Texas and is now extending eastward as far as Louisiana and Mississippi. It causes a loss of cotton to the value of more than 20 million dollars every year. The plants are healthy, but have no bolls or cotton; the weevil has taken it all. The field shown in the illustration on the next page contains a normal cotton crop ready for harvest. This field has been protected from the boll weevil by methods determined by the work of the Bureau of Entomology, U. S. Department of Agriculture.

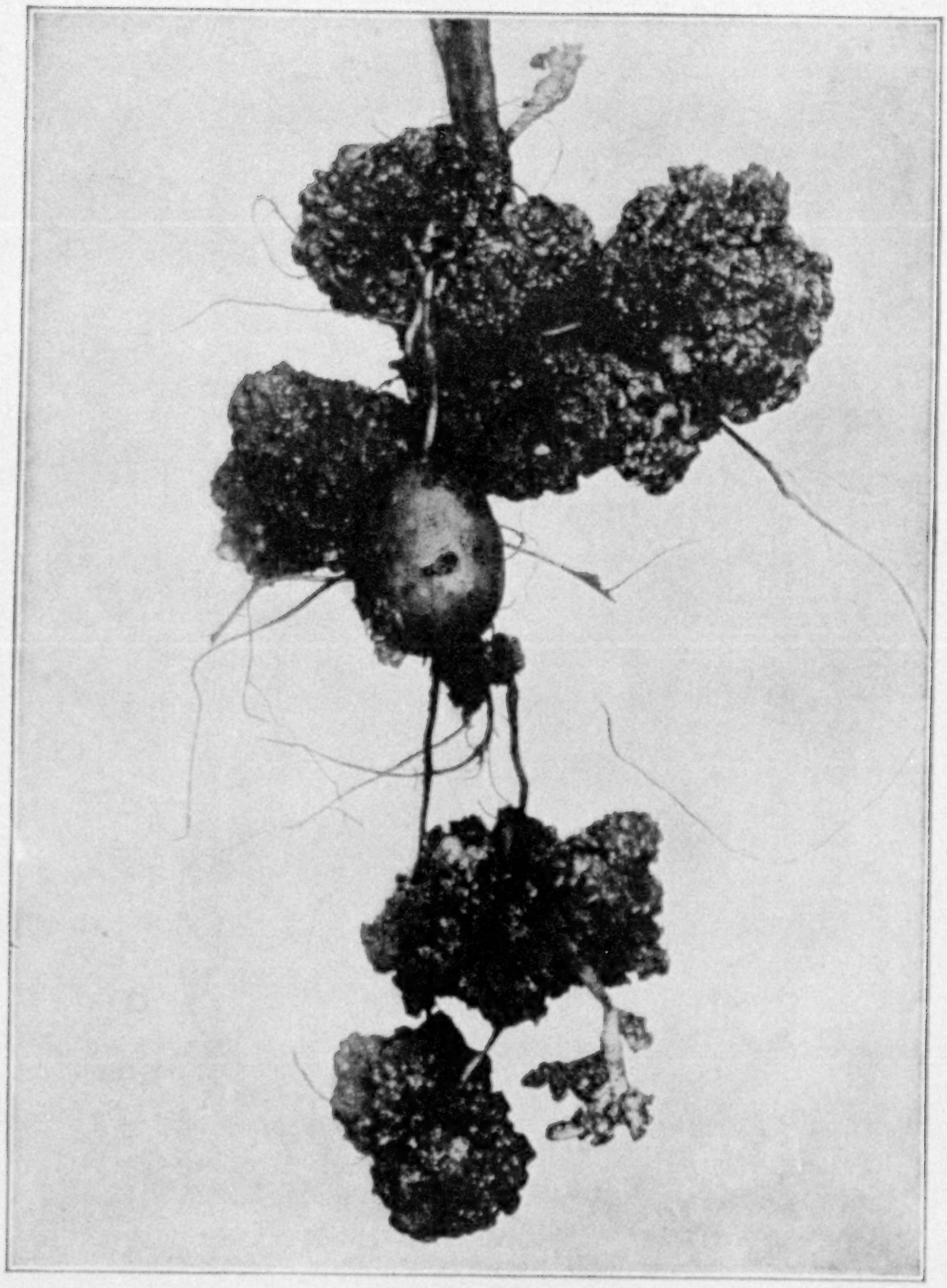
face, neck, or hands from an infested tree, but also from the myriads of hairs which are shed by these caterpillars when they transform to the chrysalis state. The hairs are carried about by winds and find lodgment on clothing, or collect on one's face, neck, or hands, and frequently cause very disagreeable and extensive nettling, the effect of which may last for months. Breathed into the lungs, they may cause inflammation and become productive of tuberculosis.

The brown-tail rash is well known throughout the regions infested in New England, and thousands have suffered from it. All of the assistants who have been connected with the government work in the New England States with these pests have been seriously poisoned, and two of them have had to give up their work and go to the Southwest to attempt to recover from the pulmonary troubles superinduced by the irritating hairs of the brown-tail moth.

This insect is therefore a most undesirable neighbor, even if it were not responsible for great injury to orchards and ornamental trees. When it is realized that the brown-tail moth has already been distributed on imported nursery stock throughout 22 States during the last two years, the danger to the whole country is sufficiently apparent.

In view of this special danger—which after all is only a continuation of the dangers and experiences to which this

This illustration shows a field on the opposite side of turn-row on the same plantation as in preceding picture, planted and treated in accordance with directions of Bureau of Entomology and yielding three-quarters bale per acre



POTATO PLANT ATTACKED BY WART DISEASE

This disease has stopped potato culture in Europe wherever it has appeared, and is now established in Newfoundland, and diseased potatoes are now coming into the United States, threatening to establish the disease here. This disease, once in the soil, stops potato culture. Its introduction into the United States would mean a loss of millions of dollars annually.

A VIEW IN FOREST PARK, BROOKLYN

Seventeen thousand chestnut trees have been killed in this park by the chestnut-bark disease, despite every effort made to save them. Photo by Haven Metcalf

country has been long subjected—a new bill was drafted and submitted to Congress for action, the passage of which would give this country great protection. It is a compromise measure—compromise in the sense that efforts have been made to meet the objections of these importing nurserymen. Its enactment will undoubtedly give this country great protection, but not absolute protection, for the simple reason that no inspection or disinfection can be guaranteed to be perfect in its results; and, in addition, there is always the risk of carelessness or venality on the part of inspectors. The bill provides for the introduction of foreign plants by permit only, for the inspection and disinfection of such stock at point of destination in this country, and, in case of need, the quarantining of foreign districts which may contain pests or diseases not possible to be excluded by inspection and disinfection.

Absolute prohibition of entry of nursery stock, except for the introduction of plants new to the United States, through the agency of the United States Department of Agriculture, is the only perfect means of preventing ultimate entrance of dangerous insects, and this is the course which has been adopted, as already indicated, by most of the foreign powers in relation to their own territory. The danger and amount of damage possible from these new pests justify the recommendation of such prohibition, especially in view of the small value of imported nursery stock in comparison with the risk and the fact that most of it at least can be just as well produced at home as abroad.

The State of California for the last 20 years has enforced a quarantine at the port of San Francisco, which is the only port in this country so guarded. During these 20 years a great many dangerous insects and diseases have been detected and stopped at this port, to the enormous gain of the fruit interests of California, and, indirectly, of the whole country.

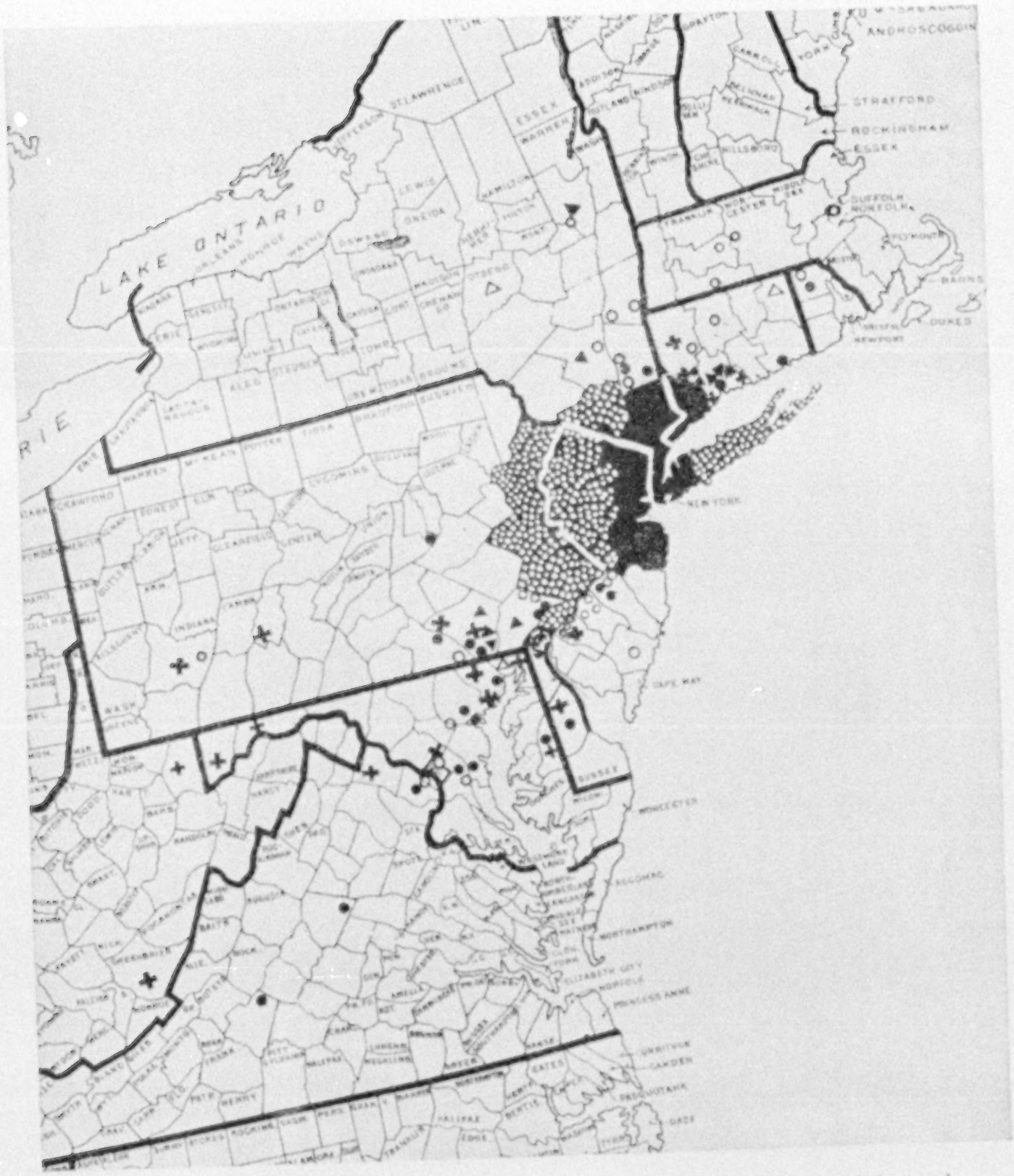
Some of our more recently developed fruit districts in the great Northwest and

ORNAMENTAL CHESTNUT TREES DYING OF THE BARK DISEASE

Trees of this size are frequently killed in one season. Photos by Haven Metcalf

DEAD CHESTNUT TREES IN FORESTS ON LONG ISLAND

This disease is carried by birds, wind, and insects, and no attacked tree ever recovers. Trees 100 years old may withstand the disease three or four years. Young trees succumb in a single year.



MAP SHOWING DISTRIBUTION OF THE CHESTNUT-BARK DISEASE (*Diaperthe parasitica* Murr.) IN DECEMBER, 1910

It was probably imported with chestnut trees from Japan. First observed in the parks of New York City in 1904, it has since rapidly spread, and now covers much of adjacent territory in lower New York, Connecticut, Long Island, New Jersey, and Pennsylvania, with widely scattered points of infestation. It is estimated that the loss in and about the city of New York is now between 5 and 10 million dollars, and the loss throughout the areas now infested is fully 100 million dollars. There is a prospective loss in Pennsylvania of fully 50 million dollars, and the entire chestnut timber of America seems to be doomed. All this might have been saved with proper quarantine laws.

EXPLANATION OF SYMBOLS

Black area. Complete infection; trees mostly dead. *Spotted area.* General infection. *Black dots.* Infection reported by specimens or observed prior to 1909. *Black crosses.* Infection reported by specimens or observed in 1909. *Black triangles.* Infection reported on reliable authority in 1909. *Circles.* Infection reported by specimens or observed in 1910. *Hollow triangles.* Infection reported on reliable authority in 1910.

some of the more newly opened Canadian provinces, profiting by past experience, have established protective quarantine regulations, which should for a long period give these regions a tremendous advantage over older fruit centers in lessening the cost of production.

It is useless now to dwell on what could have been saved to the agriculture and natural-forest resources of this continent if our forefathers had been wise enough to have early established and intelligently enforced inspection and quarantine regulations against the Old World to exclude plant diseases and insect enemies. That would have been conservation in its most practical form. The past cannot be remedied, but the future can be safeguarded, and that is the present opportunity. The first step towards securing the desired legislation is to arouse a public realization of the need. The moment this need becomes generally felt, the legislation will be forthcoming.

OUR GREATEST TRAVELERS

Birds that Fly from Pole to Pole and Shun the Darkness: Birds that Make 2,500 Miles in a Single Flight

By Wells W. Cooke

Of the Biological Survey, U. S. Department of Agriculture

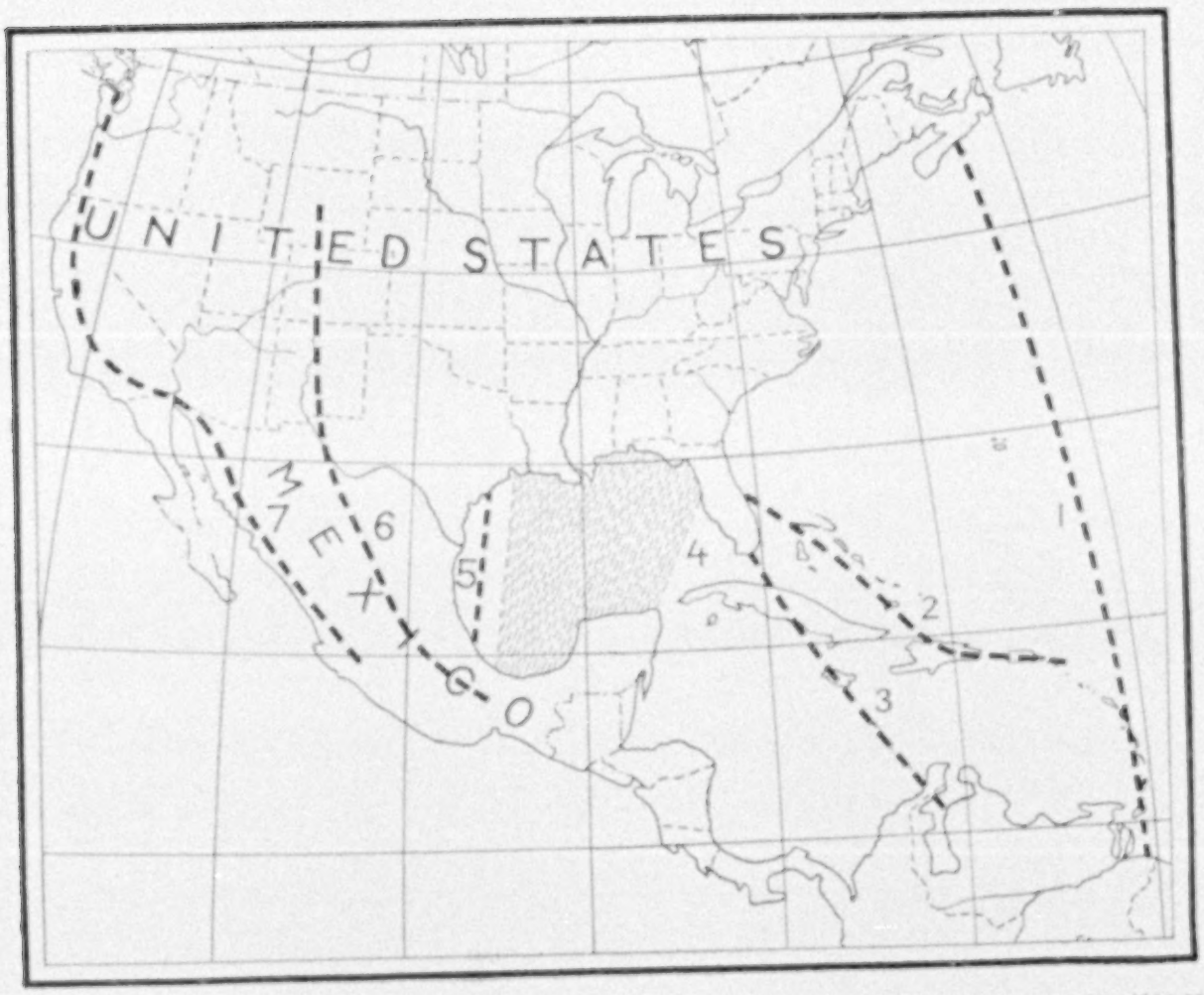
THE migration of birds has long been considered an unfathomable mystery, but late investigations have furnished abundant data on the when and where of migration and solved many of its puzzles. The Bureau of Biologic Survey of the United States Department of Agriculture has collected much information on the migration of North American birds, and this article is an attempt to put in popular form some of the data that have already appeared in the more technical bulletins and reports. No correct understanding of bird migration is possible until it is considered as a voluntary evolution. All migratory movements must have begun with changes of location, which were only very slight.

From this short migration, benefit accrued to individuals or to their posterity. Migration became a fixed habit, and the distance covered gradually—very gradually—increased as each succeeding extension proved advantageous. It is not to be supposed that every attempted extension was a success; in fact, it is more probable that only a small part of the experimental pioneering routes were permanently adopted.

Moreover, it must be borne in mind that the time occupied in the establishment of present migration habits and routes was measured in geologic ages, and there is no reason to suppose that changes took place during these ages any faster than they do now.

It is about a hundred years since the first reliable notes on migration in the United States were recorded, and this period has proven too short to show any perceptible difference in its time, direction, or speed. It can be affirmed, then, that the migration routes of today are the results of innumerable experiments as to the best way to travel from the winter to the summer home and return.

It can also be said that food supplies en route have been the determining factor in the choice of one course in prefer-



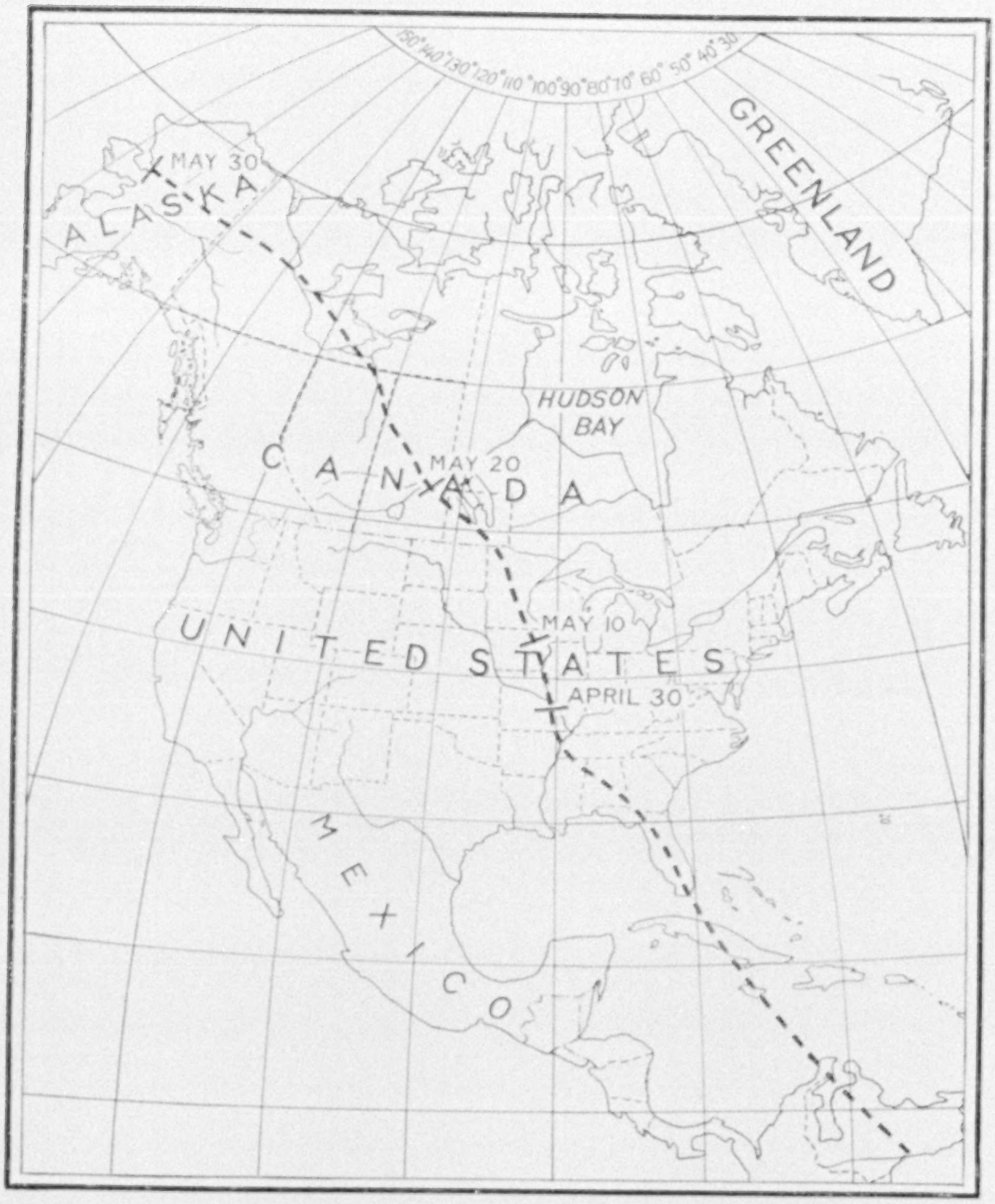
MAP SHOWING THE PRINCIPAL ROUTES USED BY BIRDS IN THEIR MIGRATIONS BETWEEN NORTH AND SOUTH AMERICA

ence to another, and not the distance from one food base to the next. The location of plenty of suitable provender having been ascertained, the birds pay no attention to the length of the single flight required to reach it.

PRINCIPAL MIGRATION ROUTES OF NORTH AMERICA

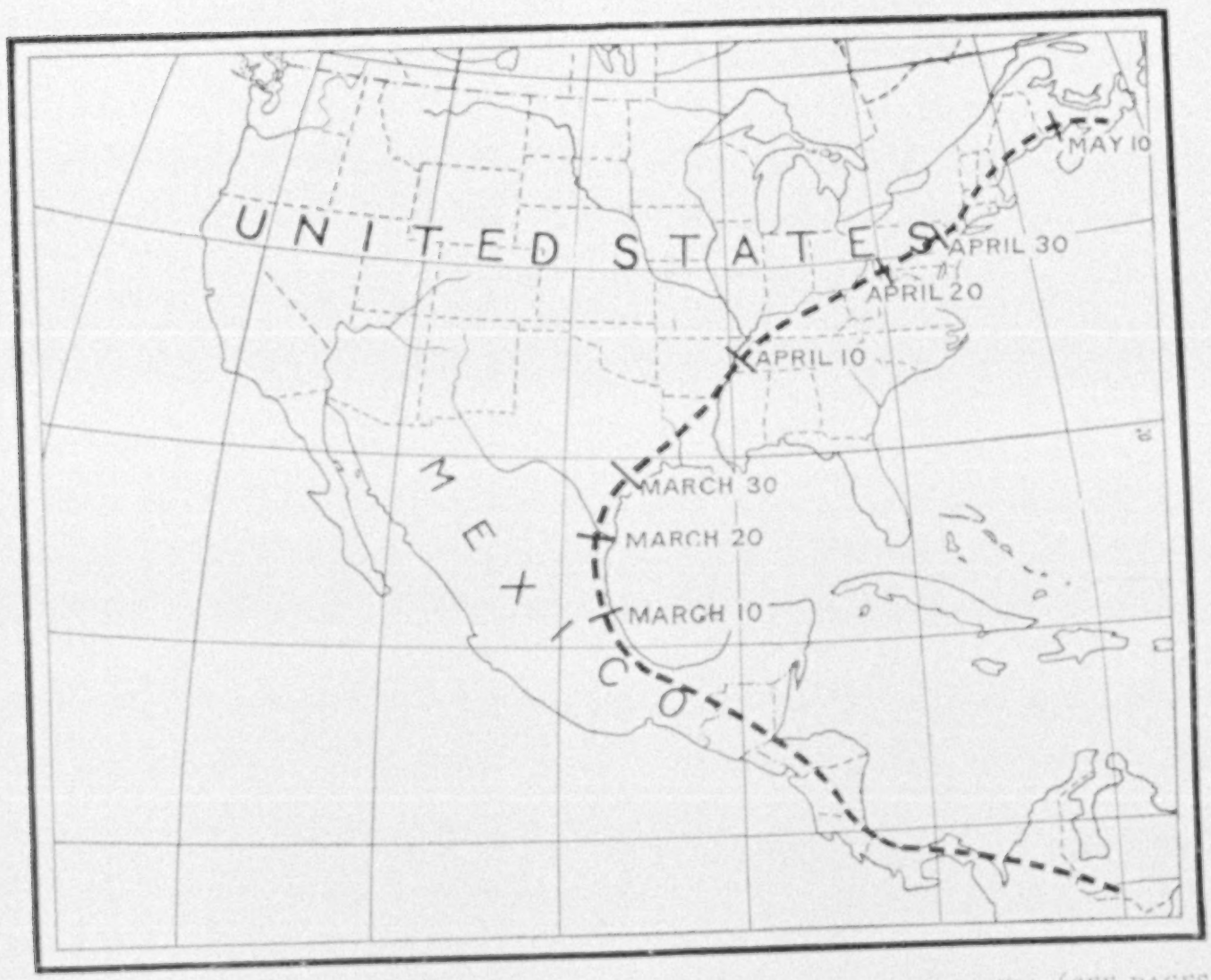
The shape of the land areas in the northern half of the Western Hemisphere has tended to great variations in migratory movements. If the whole area from Brazil to Canada were a plain with the general characteristics of the middle section of the Mississippi Valley, the study of bird migration would lose much of its fascination. There would be a simple rhythmical swinging of the migration pendulum back and forth spring and fall. But a large part of the space between Brazil and Canada is occupied by the Gulf of Mexico, the Caribbean Sea, and parts of the Atlantic Ocean, all devoid of sustenance for land birds. The two areas of abundant food supplies are North America and northern South America, separated by the comparatively small land areas of Mexico and Central America, the islands of the West Indies, and the great stretches of foodless waters.

The different courses taken by the birds to get around or over this intervening inhospitable region are almost as numerous as the bird families that traverse them, and only some of the more important ones are shown on the accompanying map (page 347). The routes are numbered from the east westward, the middle one, No. 4, being by far the most important. In general it may be said to extend from northwestern Florida and western Louisiana across the Gulf of Mexico to the southern coast of the Gulf (Yucatan to Vera Cruz), and



MIGRATION ROUTE OF THE BLACK-POLL WARBLERS THAT NEST IN ALASKA

This bird winters in South America alongside the cliff swallow, but in summer seems to try and get as far as possible from its winter neighbor. Note how its northward route diverges from the northward flight of the cliff swallow, shown on the map on the opposite page. It travels at night, often flying several hundred miles in the darkness (see pages 349, 351, and 363).



MIGRATION ROUTE OF THE CLIFF SWALLOWS THAT NEST IN NOVA SCOTIA (SEE PAGES 348, 351, AND 365)

The swallow, unlike the warbler, travels by day

thence by land through Central America to South America. Probably more individuals follow this route than all the other routes combined.

The birds east of the Alleghany Mountains move southwest in the fall approximately parallel with the seacoast, and most keep this same direction across the Gulf to eastern Mexico. The birds of the central Mississippi Valley go southward to and over the Gulf. The birds between the Missouri River and the edge of the plains, and those of Canada east of the Rocky Mountains, move southeastward and south until they join the others in their passage of the Gulf.

In other words, the great majority of North American birds bound for a winter's sojourn in Central or South America elect a short cut across the Gulf of Mexico in preference to a longer land journey by way of Florida or Texas. In fact, millions of them cross the Gulf at its widest part, which necessitates a single flight of 500 to 700 miles.

The peninsula of Florida extends far to the south, and the great island of Cuba forms a convenient stepping-stone between its coast-line and Yucatan. A bird taking this highway would avoid any long single flight; yet, with the exception of a few day-migrating swallows, no bird is known to follow this route. A probable explanation is that southern Florida has vastly less bird food per square mile than the country to the

northward, and the birds prefer a single long flight with abundant rations to a series of shorter flights on scantier fare.

Migration route No. 3, which is by way of Cuba and Jamaica, offers a much shorter journey to South America, but it is traversed by only a few species. It is popular as far as Cuba with some 60 species, of whom great numbers spend the winter on the island; about 30 of these species have a small contingent who pass on to make Jamaica their winter resort; but scarcely more than 10 species try the final long flight across the Caribbean Sea to South America. Among these are one species each of six widely differing families—the bank swallow, gray kingbird, Florida nighthawk, Alice thrush, blackpoll warbler, and bobolink. The other members of those families employ entirely different migration routes.

It is not possible to ascertain whether these travelers on the so-called "bobolink route" represent adventurous species that are seeking to improve on the roundabout course through Mexico, or old fogies who hold to the way of their forefathers long after their brethren have proven to their own satisfaction the superior advantages of the more western route.

The next route to the eastward, No. 2, traverses the chain of islands that extend from Florida to South America. This, too, is considerably shorter than the Florida-Yucatan route, and land can always be kept in sight; yet this line also is discredited. A few individuals of about 25 species follow it as far as Porto Rico, and only 6 of these continue to the South American coast, and these last in such diminished numbers as to form an insignificant fraction of the winter visitants in that region.

The explanation, of course, lies in the question of food. The combined area of all the West India islands east of Porto Rico is so small that it could not furnish subsistence for even one per cent of the myriads of birds which throng the main migration route across the Gulf.

To the westward the short route, No. 5, stretches a few hundred miles from the coast of Texas to northern Vera Cruz. It is adopted by a few Kentucky warblers, worm-eating warblers, golden-wing warblers, and some others, who seek in this way to avoid a slow journey by land across a region scantily supplied with moist woodlands.

Still farther west, routes 6 and 7 represent the land journeys of those birds from the western United States who winter in Mexico and Central America. Their trips are comparatively short; most of them are content to stop when they have reached the middle districts of Mexico, and only a few pass east of the southern part of that country.

Route No. 1 remains to be noticed. It extends in an approximately north-and-south line from Nova Scotia to the Lesser Antilles and the northern coast of South America. Though more than a thousand miles shorter than the main migration route, it is not employed by any land bird. But it is a favorite fall route for thousands of water birds, and as such will be referred to again more in detail.

It must not be considered that these routes as outlined on the map represent distinctly segregated pathways with clearly defined borders. On the contrary, they are merely convenient subdivisions of the one great flightway which extends from North to South America. There is probably no single mile in the whole line between northern Mexico and the Lesser Antilles which is not crossed each fall by migrating birds. What is meant is that the great bulk of the birds, both as to species and number of individuals, cross the Gulf to eastern Mexico, while to the eastward their numbers steadily diminish.

LIGHT-HOUSES LURE THOUSANDS OF BIRDS TO DESTRUCTION

It is not to be supposed that these long flights over the waters can occur without many casualties, and not the smallest of the perils arises from the beacons which man has erected along the coast to insure his own safety. "Last night I could have filled a mail-sack with the bodies of little warblers which killed themselves striking against my light," wrote the keeper

of Fowey Rocks light-house, in southern Florida.

Nor was this an unusual tragedy. Every spring the lights along the coast lure to destruction myriads of birds who are en route from their winter homes in the South to their summer nesting places in the North. Every fall a still greater death-toll is exacted when the return journey is made.

Light-houses are scattered every few miles along the more than 3,000 miles of our coast-line, but two light-houses—Fowey Rocks and Sombrero Key—are responsible for far more bird tragedies than any others. The reason is twofold: their geographic position and the character of their lights. Both are situated at the southern end of Florida, where countless thousands of birds pass each year to and from Cuba. Both lights are of the first magnitude, on towers 100-140 feet high, and Fowey Rocks has a fixed white light, the deadliest of all.

A red light or a rapidly flashing one repels the birds, but a steady white light piercing the storm and fog proves irresistible. From whatever direction they approach they veer to windward, and then, flying against the wind, seek the object of their infatuation. The larger part do not strike with sufficient force to injure themselves, but, like great moths, they flutter in and out of the light's rays, and finally settle on the platform or framework to await the abatement of the storm or the coming of sufficient daylight to enable them once more to orient themselves.

NEIGHBORS IN WINTER AND REMOTE STRANGERS IN SUMMER

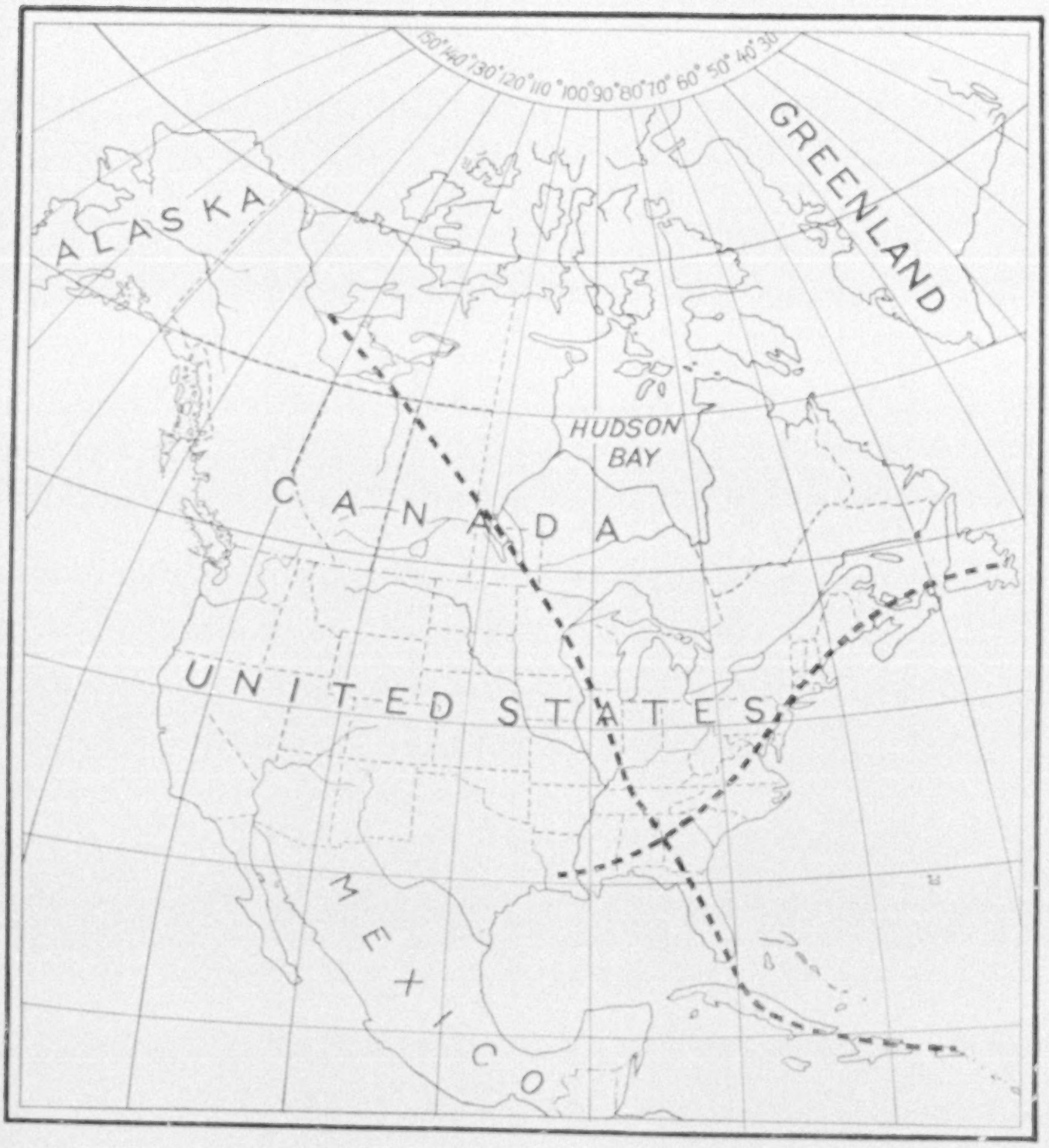
The next two maps (pages 348 and 349) show the extremes of direct and circuitous routes of migration. All black-poll warblers winter in South America. Those that are to nest in Alaska strike straight across the Caribbean Sea to Florida and go northwestward to the Mississippi River. Then the direction changes and a course is laid almost due north to northern Minnesota, in order to avoid the treeless plains of North Dakota. But when the forests of the Saskatchewan are reached, the northwestern course is resumed and, with a slight verging toward the west, is held until the nesting site in the Alaska spruces is attained.

The cliff swallows are winter neighbors in South America of the black-poll warblers. But when in early spring nature prompts the swallows who are to nest in Nova Scotia to seek the far-off land where they were hatched, they begin their journey to that region—which is situated exactly north of their winter abode—by a westward flight of several hundred miles to Panama. Thence they move leisurely along the western shore of the Caribbean Sea to Mexico and, still avoiding any long trip over water, go completely around the western end of the Gulf. Hence as they cross Louisiana they are moving in the opposite direction from that in which they started. A northeasterly course from Louisiana to Maine, and an easterly one to Nova Scotia, completes their spring migration. This circuitous route has added more than 2,000 miles to the distance traveled.

THE WARBLER TRAVELS AT NIGHT, THE SWALLOW BY DAY

Why should the swallow elect so much more roundabout a route than that taken by the warbler? The explanation is simple. The warbler is a night migrant. Launching into the air soon after nightfall, it wings its way through the darkness toward some favorite lunch station, usually several hundred miles distant, where it rests and feeds for several days before undertaking the next stage of its journey. Its migration consists of a series of long flights from one feeding place to the next, and naturally it takes the most direct course between stations, not deviating for any body of water that can be compassed at a single flight.

On the other hand, the swallow is a day migrant. Little and often is its rule. It begins its spring migration several weeks earlier than the warbler and catches each day's rations of flying insects during a few hours of slow evolutions, which at the same time accomplish



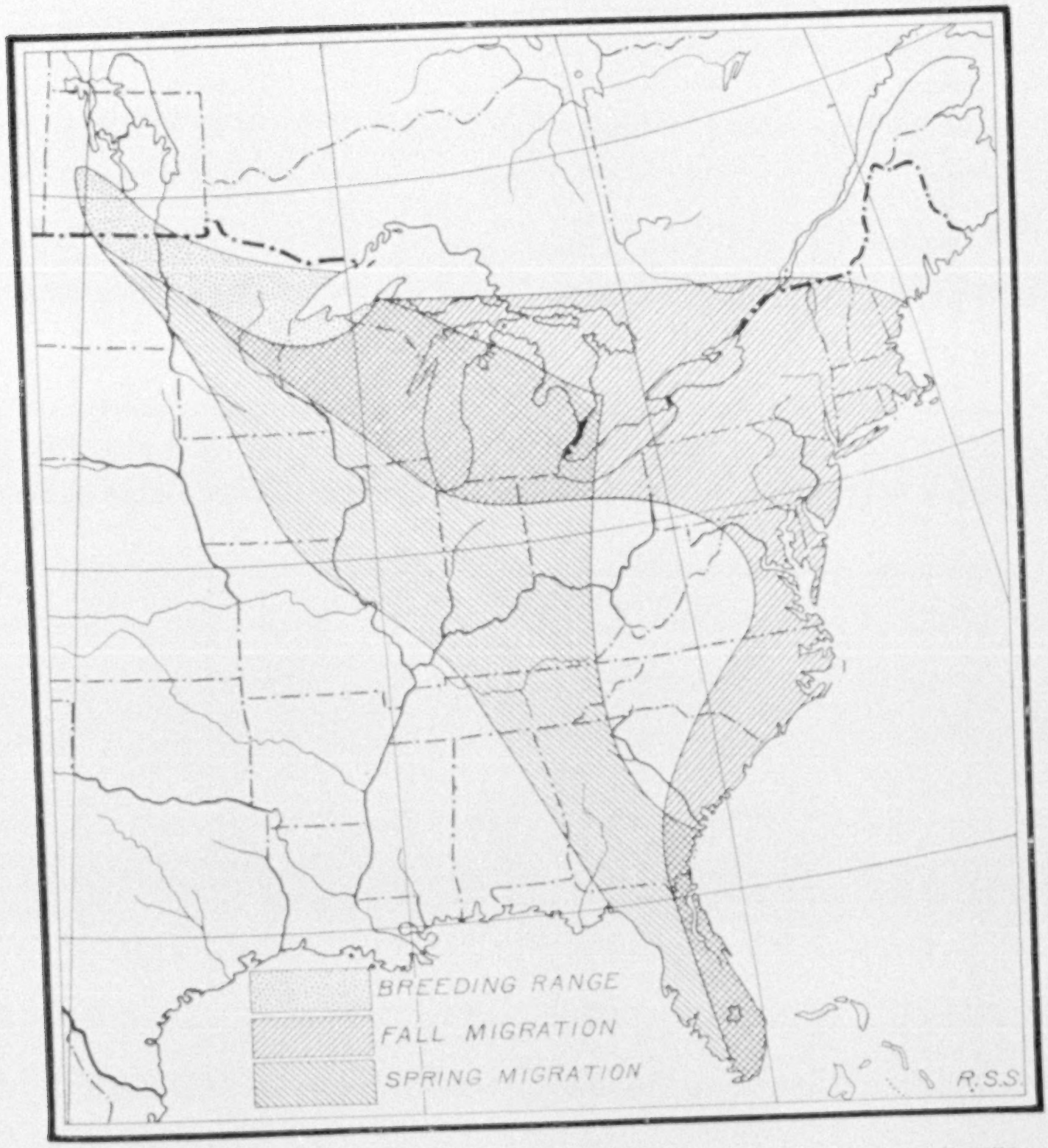
TWO OF THE PRINCIPAL MIGRATION ROUTES OF THE PALM WARBLER

They winter in the Gulf States from Louisiana eastward and throughout the Greater Antilles to Porto Rico. The Louisiana birds nest in Labrador, and those from the Antilles cut diagonally across the United States to summer in central Canada. The two routes cross each other in Georgia at approximately right angles.

the work of migration. It keeps along the insect-teeming shores, and the 2,000 extra miles thereby added to the migration route are but a tithe of the distance covered in pursuit of its daily food.

IDIOSYNCRASIES IN MIGRATION ROUTES

How migrating birds find their way over the widespread regions lying between their winter and summer homes has always been one of the tantalizing



THE CONNECTICUT WARBLER CHOOSES A DIFFERENT ROUTE TO RETURN TO ITS WINTER HOME THAN IT USED WHEN LEAVING IN SPRING (SEE PAGE 355)

problems of the migration student. A favorite theory of the past, and one still claiming many advocates, is that river valleys and mountain chains form convenient highways along which the birds travel in the spring, and which are easily recognized on the return trip.

The incorrectness of this theory (at least with reference to some species) is proven by the migration routes of the palm warblers. They winter in the Gulf States from Louisiana eastward and throughout the Greater Antilles to Porto Rico. They nest in Canada from the Mackenzie Valley to Newfoundland. To carry out the above theory, the Louisiana

THE LONGEST SINGLE FLIGHT MADE BY ANY BIRD—2,500 MILES ACROSS THE OCEAN FROM NOVA SCOTIA TO SOUTH AMERICA

This map shows the migration route of the golden plover, which uses a different course on its return from its winter home (see page 355)

palm warblers should follow up the broad, open highway of the Mississippi River to its source and go thence to their breeding grounds, while the warblers of the Antilles should use the Alleghany Mountains as a convenient guide.

As a matter of fact, as shown on the map (page 352), the Louisiana birds nest in Labrador, and those from the Antilles cut diagonally across the United States to summer in central Canada. The two routes cross each other in Georgia at approximately right angles.

Another idiosyncrasy of bird migration is the adoption by the Connecticut warbler of different routes for its southward and northward journeys. All the individuals of this species winter in South America, and, as far as known, all go and come by the same direct route between Florida and South America, across the West Indies; but north of Florida the spring and fall routes diverge. The spring route (page 353) leads the birds up the Mississippi Valley to their summer home in southern Canada; but fall migration begins with a 1,000-mile trip almost due east to New England, whence the coast is followed southwest to Florida.

The Connecticut warbler is considered rare, but the multitudes that have struck the Long Island light-houses during October storms show how closely the birds follow the coast-line during fall migration.

The map represents the spring-migration route as far as at present known. The fact that the route is practically north and south through Ohio and then turns abruptly west indicates a large and as yet undiscovered breeding area in Ontario north of lakes Huron and Superior. Indeed, so little is known about the nesting of the Connecticut warbler that the eggs obtained by Mr. Seaton more than 25 years ago still remain unique.

Incidentally this route of the Connecticut warbler is a conclusive argument against the theory that migration routes indicate the original pioneer path by which the birds invaded the region of their present summer homes.

THE LONGEST CONTINUOUS FLIGHT IN THE WORLD—2,500 MILES

Such elliptical migration routes as that mentioned above are rare among land birds, but are used and on a far larger scale by many water birds, notable among which is the golden plover. This species nests along the Arctic coast of North America, and as soon as the young are old enough to care for themselves fall migration is begun by a trip to the Labrador coast, where the plover fattens for several weeks on the abundant native fruits. A short trip across the Gulf of St. Lawrence brings it to Nova Scotia, the starting point for its extraordinary ocean flight, due south to the coast of South America (page 354).

The golden plover takes a straight course across the ocean, and, if the weather is propitious, makes the whole 2,400 miles without pause or rest. But if tempests arise, it may be blown out of its course to the New England coast and start anew on the advent of fair weather; or it may rest for a few days at the Bermudas, one-third of the way along its course, or at the nearest of the Lesser Antilles, still 600 miles from the mainland of South America. These, however, are emergency stop-overs, to be resorted to only in case of storms. Having accomplished its ocean voyage, it passes across eastern South America to its winter home in Argentina.

After a six months' vacation here, the plover finds its way back to the Arctic by an entirely different route. It travels across northwestern South America and the Gulf of Mexico, reaching the United States along the coasts of Louisiana and Texas. Thence it moves slowly up the Mississippi Valley and by early June is again at the nesting site on the Arctic coast. Its round trip has taken the form of an enormous ellipse, with a minor axis of 2,000 miles and a major axis stretching 8,000 miles from Arctic America to Argentina.

HOW DID THE GOLDEN PLOVER COME TO USE SUCH A DIFFICULT ROUTE?

The evolution of the elliptical route of the golden plover, wonderful though it is in its present extended form, is easily traced through its various stages. Toward the end of the glacial era, when the ice began to recede, the peninsula of Florida was submerged and a comparatively small area of land in the southeastern United States was free from ice. Any golden plover that attempted to follow up the retreating ice must have been confined to an all-land route from Central America through Mexico and Texas to the western part of the Mississippi Valley. As larger areas of the eastern United States were uncovered and became available for bird habitation, extension of the route would be to the northeast, until in time the whole of the Mississippi Valley to the Great Lakes could be occupied.

As the migration route lengthened and powers of flight developed, there would arise a tendency to straighten the line and shorten it by cutting off some of the great curve (No. 1, page 357) through Texas and Mexico. A short flight across the western end of the Gulf of Mexico was finally essayed (No. 2), and this gradually lengthened and its points of departure and arrival moved eastward until eventually the roundabout curve through Texas was discarded and the flight was made directly from southern Louisiana across the Gulf (No. 3).

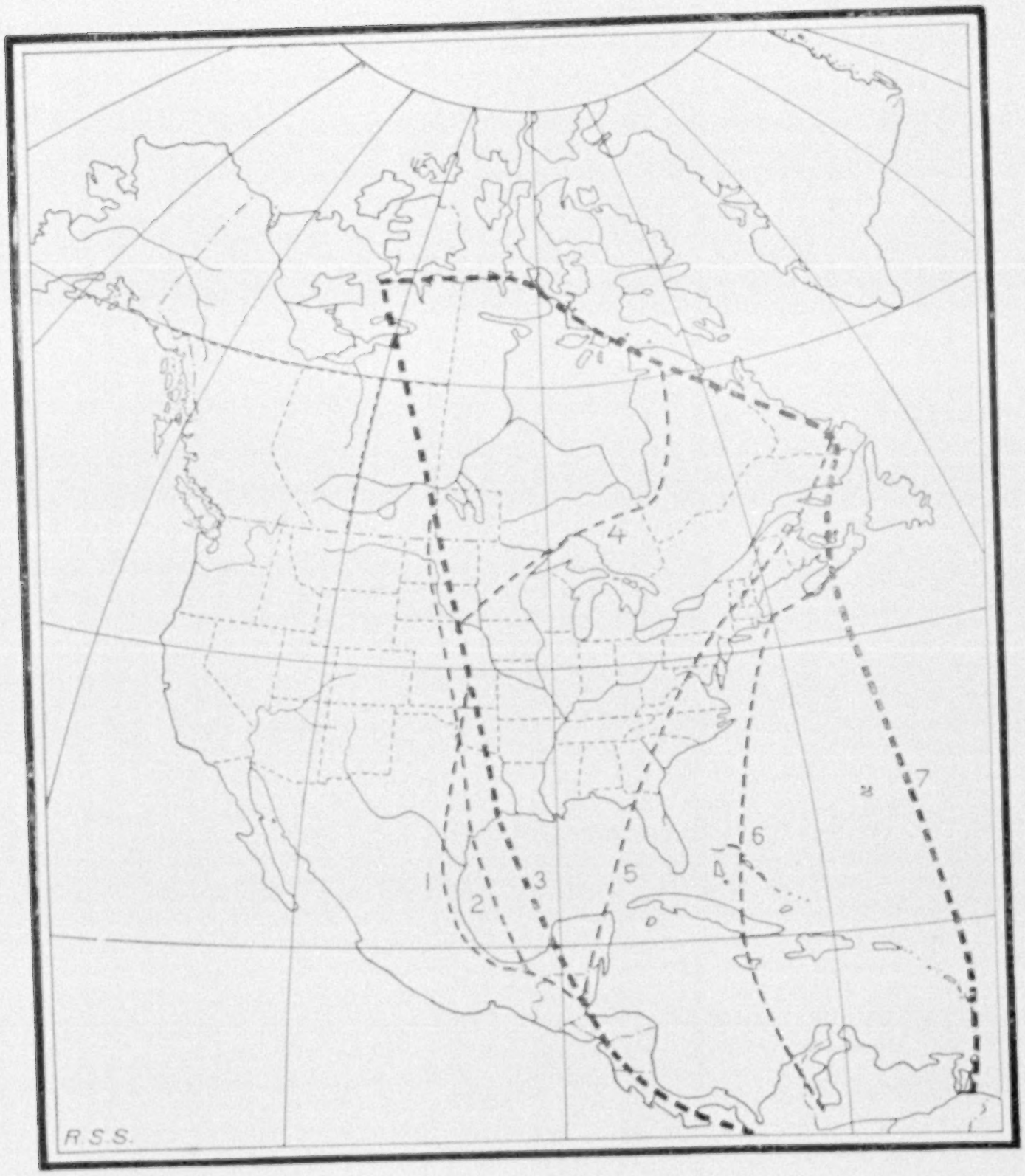
As the great areas of Canada were added to the birds' domain, other conditions arose. Here appeared a vast new stretch of coast and plain—the Labrador peninsula—offering in the fall rich stores of the most delectable berries and fruits; but at migrating time, in the spring, bound by frost and shrouded in fog. Since Chinook winds made the climate of the interior of the continent just east of the Rocky Mountains especially favorable for spring migration, there arose gradually a dividing of the spring and fall routes, the fall route tending eastward (No. 4), while the spring route remained unchanged. When the fall route had worked eastward to the Gulf of St. Lawrence (No. 5), a shortening began to take out the great westward curve of the New England coast. A short ocean flight was attempted (No. 6); and, when this proved successful, it was extended until the present direct route (No. 7) across the Atlantic was obtained.

HOW DOES THE PLOVER FIND ITS WAY EVERY SEASON TO THE LITTLE HAWAIIAN ISLANDS, 2,400 MILES ACROSS THE OCEAN?

The above gives a probable and fairly satisfactory explanation of the origin of the present migration route of the golden plover over the Atlantic Ocean. But this is a very simple problem compared with that presented by the Pacific golden plover. The Hawaiian Islands are in the middle of the Pacific Ocean, distant 2,000 miles from California on the east, 2,400 miles from Alaska on the north, and 3,700 miles from Japan to the west. Golden plover in considerable numbers fly each fall the 2,400 miles across an islandless sea from Alaska to Hawaii, spend the winter there, and fly back again the next spring to nest in Alaska. But how did they first find their way to Hawaii?

It is not to be supposed that any birds would deliberately strike out over unknown seas hunting for a new winter home. It is scarcely more probable that, even if a large flock was caught in a storm and carried far out of its course to the Hawaiian shores, the birds would change in a single season habits of countless generations and start at once a radically new migration route. It has already been said that present migration routes are evolutions—age-long modifications of other routes. The problem, then, is to find some migration route from which the golden plover's present Hawaiian-Alaskan route could have been easily and naturally derived.

The bird breeds on the northern shores of eastern Siberia, from the Liakof Islands to Bering Strait, and on the Alaska side of the strait south to the northern



MAP SHOWING THE EVOLUTION OF THE PRESENT MIGRATION ROUTE OF THE GOLDEN PLOVER (SEE PAGE 356)

base of the Alaska peninsula (page 359). It winters on the mainland of southeastern Asia, in the eastern half of Australia, and throughout the islands of Oceanica, from Formosa and the Liu Kiu Islands on the northwest to the Low Archipelago in the southeast.

The breeding range has an east-and-west extension of about 1,700 miles, while the winter home extends nearly half around the globe—10,000 miles—from India to the Low Archipelago. Undoubtedly the original migration route was approximately north and south, be-

tween the nests in Siberia and the winter resorts in southern Asia. In the course of time the species spread eastward in the winter to Australia, to the islands along the eastern coast of Asia, and throughout Oceanica, while at the same time the breeding range was extended eastward across Bering Strait to Alaska.

If all these extensions took place before there was any cutting off of corners in the migration route, then at this stage of development the Alaska-breeding birds were journeying over 11,000 miles (page 359, No. 1) to reach the Low Archipelago, distant only a little more than 5,000 miles in an air-line.

It is fair to suppose that early in the course of the eastward extension among the Pacific islands, the plover began to shorten the roundabout journey by flights from the northern islands to eastern Asia, and finally to Japan (No. 2). The most northern island is Palmyra, and the flight from there westward to the nearest of the Marshall Islands is about 2,000 miles; thence a 3,000-mile journey, with several possible rests, brings the birds to Japan.

It is easily possible that birds accustomed to this 5,000-mile flight might be driven by storms a thousand miles out of their course and discover Hawaii. When from Hawaii they attempted to reach Japan (No. 3) they would find a chain of islands stretching for 1,700 miles in the desired direction, and the final flight of 2,000 miles from the last of these—the Midway Islands—to Japan would be no longer than previous flights to which they had become accustomed.

Having once learned the route from the Midway Islands to Japan, it would be natural that the place of alighting on the Asiatic coast should be gradually carried north and east until the direct flight was made from the Midway Islands to the Aleutians (No. 4). A natural and easy carrying of this line eastward would result in the present route (No. 5) between Hawaii and Alaska.

NEIGHBORS AND STRANGERS

Both the American and Pacific golden plovers nest in Alaska near Bering Strait, the former on the north and the latter on the south side of the strait. The American bird reached there by a westward extension from Canada, and the Pacific by an eastward extension from Siberia. The birds themselves are so nearly alike that only an expert can distinguish them; and, notwithstanding they are such near neighbors during the summer—scarcely a hundred miles apart—the beginning of migration makes them utter strangers; for those north of the strait travel 3,000 miles east and then 6,000 miles south to Argentina, while the others make a 3,000-mile flight directly south to their winter home in Hawaii.

THE WORLD'S MOST EXTRAORDINARY TRAVELER

The shore-birds, such as the golden plover, present the longest migration routes among land-feeding birds; but even their surprising records are surpassed by some of the birds which glean their living from the waters. The world's migration champion is the Arctic tern (page 360). It deserves its title of Arctic, for it nests as far north as land has been discovered; that is, as far north as the bird can find anything stable on which to construct its nest.

Indeed, so Arctic are the conditions under which it breeds that the first nest found by man in this region, only 7½ degrees from the pole, contained a downy chick surrounded by a wall of newly fallen snow that had been scooped out of the nest by the parent.

When the young are full grown the entire family leaves the Arctics, and several months later they are found skirting the edge of the Antarctic continent.

What their track is over that 11,000 miles of intervening space no one knows. A few scattered individuals have been noted along the United States coast south to Long Island, but the great flocks of thousands and thousands of these terns which alternate from one pole to the other have never been met by any trained ornithologist competent to learn their preferred path and their time schedule.

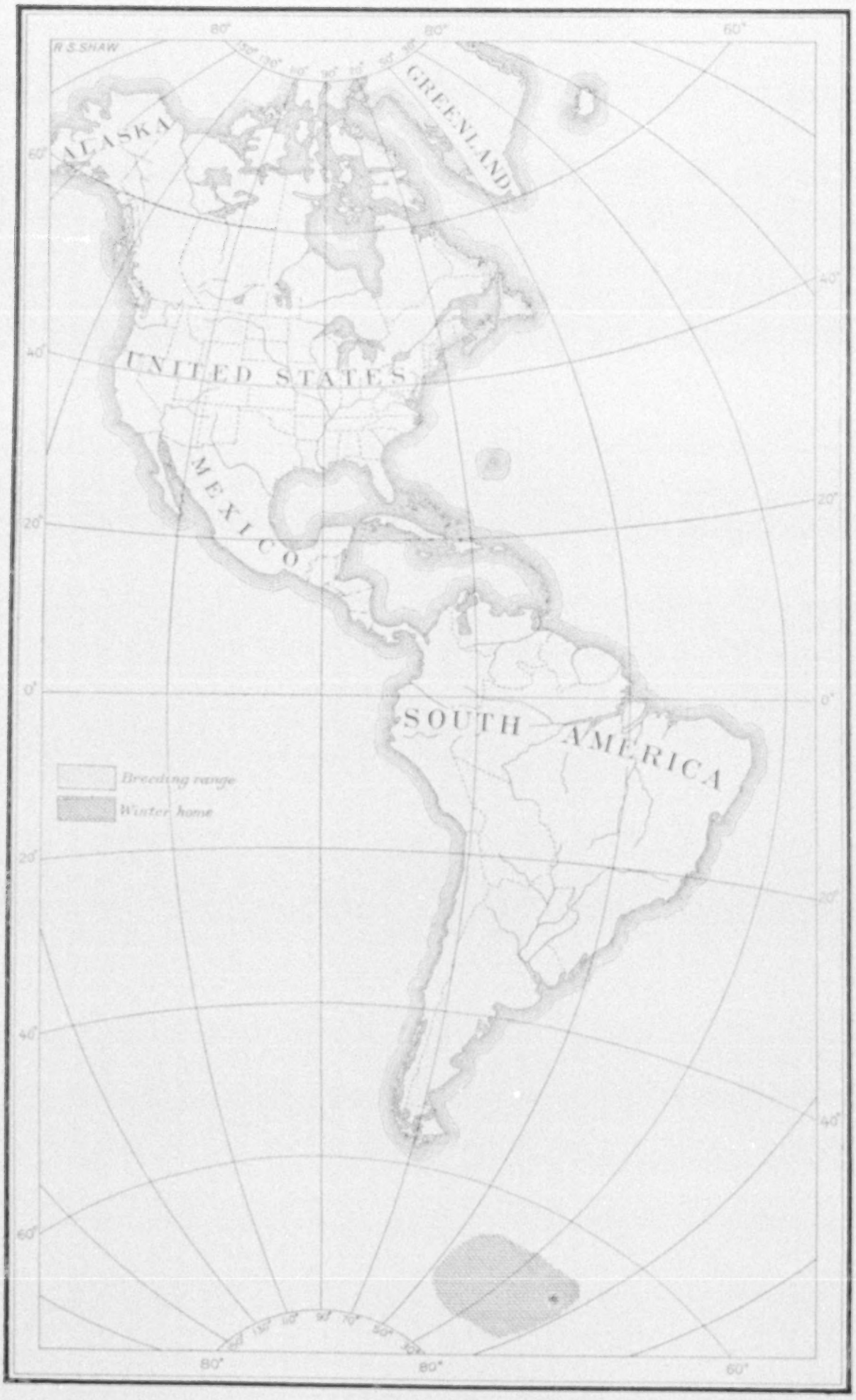
The Arctic terns arrive in the far north about June 15 and leave about August

MAP TO EXPLAIN HOW THE GOLDEN PLOVER IS ABLE TO NAVIGATE TO THE HAWAIIAN ISLANDS IN THE MID-PACIFIC (SEE PAGES 356 AND 358)

The longest ocean trip without any possibility of resting is shown in this map. This is the same distance as traversed by the Atlantic plover, but the latter can get to land when in trouble. The dotted lines along the Arctic coast show the breeding range of the bird.

25, thus staying 14 weeks at the nesting site. They probably spend a few weeks longer in the winter than in the summer home; and, if so, this leaves them scarcely 20 weeks for the round trip of 22,000 miles. Not less than 150 miles in a straight line must be their daily task, and this is undoubtedly multiplied several times by their zigzag twistings and turnings in pursuit of food.

The Arctic terns have more hours of daylight and sunlight than any other animals on the globe. At their most northern nesting site, the midnight sun has already appeared before their arrival, and it never sets during their entire stay at the breeding grounds. During two months of their sojourn in the Antarctic they do not see a sunset, and for the rest of the time the sun dips only a little



MAP SHOWING SUMMER AND WINTER HOMES OF THE BIRD THAT HATES DARKNESS

The summer home of the Arctic tern is along the Arctic coast of North America; its winter home within the Antarctic Circle, 11,000 miles away. During eight months of the year the bird lives where the sun does not go below the horizon. The track of the tern in its round journey of 22,000 miles is unknown (see page 359).

way below the horizon and broad daylight continues all night. The birds therefore have 24 hours of daylight for at least eight months in the year, and during the other four months have considerably more daylight than darkness.

THE MOVEMENTS OF THE ROBIN

The number of miles traveled per day by a migrating bird varies greatly in different parts of the migration journey. These variations are intimately connected with corresponding variations in the speed of the northward march of spring, and are based primarily on two facts: First, that the interior of a continent warms up faster than the coasts; second, that spring is hastened in western North America by the Japan current, while it is as decidedly retarded in the east by the polar current.

The results of these two causes are strikingly shown in the migration of the robin (page 362). This bird differs from most others in that throughout its entire course northward it adopts spring's timetable for its own.

The robin's average temperature of migration is 35° F.; that is, it puts in an appearance soon after the snow begins to melt and streams to open, but before vegetation has made any start. These conditions occur in the central Mississippi Valley about the middle of February, and it is the first of March before spring and the robins cross northern Missouri and arrive together in southern Iowa. Thence a whole month is consumed by the birds in their slow progress—13 miles a day—to central Minnesota. There their pace quickens, to keep up with the northward rush of spring, and another 10 days at doubled speed brings them to southern Canada.

Here they must make an important choice. To the north and northeast lies a land that awakens slowly from its winter's sleep, and where the sun must wage a protracted contest against the cold of the ice-masses in Lake Superior and Hudson Bay. To the northwest stretches a less forbidding region, already quickening under the influence of the Chinook winds.

THE EASTERN ROBINS MOVE SLOWLY, THE PACIFIC MUCH FASTER

Most of the robins from Missouri that pass through western Minnesota elect to turn to the northwest, and now they must not only keep pace with the rapidly advancing season, but must do so while traveling on a long-drawn-out diagonal. Their daily average rises to 50 miles—four times that in southern Iowa—and later, when for the birds bound for western Alaska the course becomes nearly due west, the rate increases to 70 miles a day—more than six times the speed with which the journey began.

The migration map of the robin shows that these Alaska-breeding birds are the only ones that develop high speed. The robins bound for Newfoundland move leisurely along the Atlantic coast at the proverbially slow rate of the oncoming of spring in New England, and, scarcely exceeding 17 miles a day, they finally arrive at their destination May 6, when their Alaska-bound relatives are already 1,200 miles farther north.

One of the most interesting things indicated on the map is the migration route of the robins who nest in southern Alberta. They arrive too early to have come from the south or the southeast; hence they must have come from the southwest, though this has necessitated their crossing the main range of the Rockies while the mountains were still in the grasp of winter. Robins remain all winter on the Pacific coast, north to southwestern British Columbia, which has about the same winter temperature as St. Louis, 700 miles southward. Hence the wintering robins of British Columbia are already far north at the advent of spring and do not need any hurried migration to reach Alberta on time. As a fact, they average only 8 miles a day, the slowest rate for the species.

It may be fairly asked, How do we know that the Alaska robins have come all this long distance from the central Mississippi Valley, instead of the far shorter distance from British Columbia? It happens that the robins of the two sides of the continent are slightly differ-

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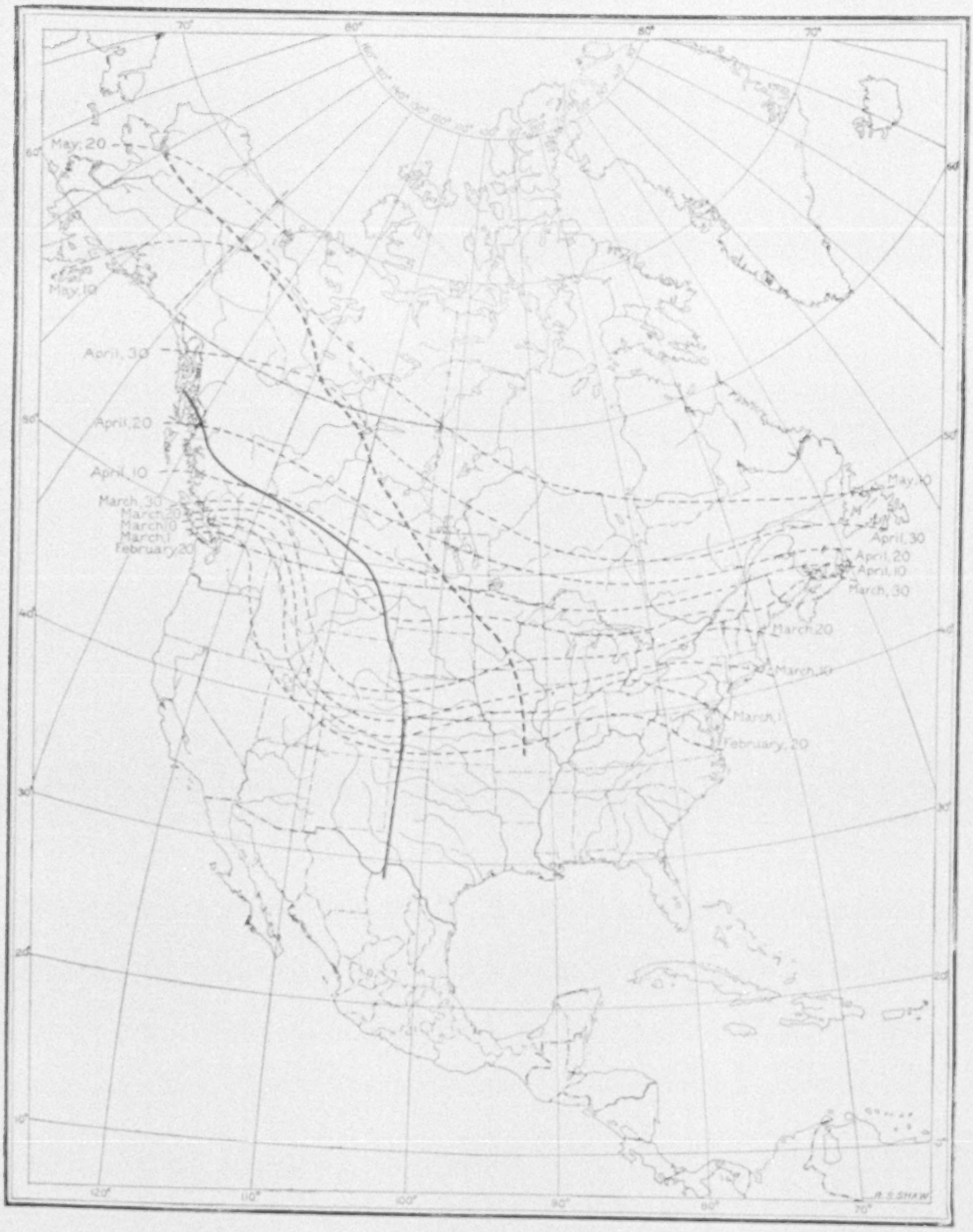
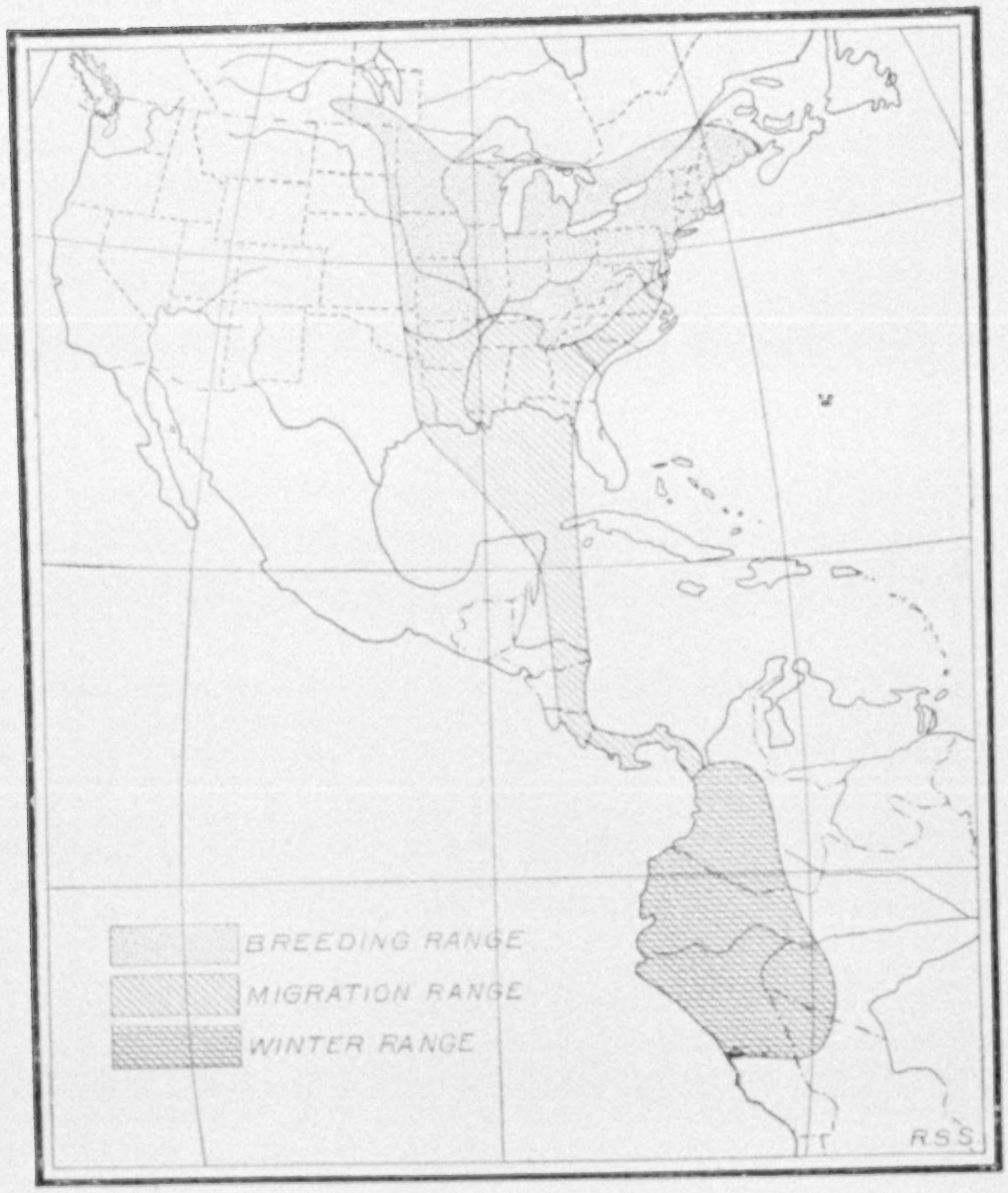


THE ROBIN MOVES MUCH QUICKER ON THE PACIFIC THAN ON THE ATLANTIC

The dotted lines connect the places at which the robins arrive simultaneously. The heavy solid line marks the division between the eastern and the western forms. The heavy dotted line represents the migration route of the Alaska breeding birds (see page 361).



THE SCARLET TANAGER

An example of a migration route much more contracted than either the breeding or winter range (see page 364)

ent in color and in pattern of coloration. Birds of the western style are not known north of southwestern Saskatchewan, central British Columbia, and southeastern Alaska, while the whole country to the northward is occupied by birds that evidently have come from the southeast. The heavy, solid line on the map shows the approximate meeting-ground of the two forms.

Most migrants except the robins, ducks, and geese wait in their warm winter quarters until springtime is far advanced, and then, traveling swiftly, occupy only a few days in their vernal migration. The black-poll warbler is one of the best examples.

THE WARBLERS AND CLIFF SWALLOWS

While the Alaska-breeding robins start off in February, and spend nearly 90 days in going from central Missouri to western Alaska, the black-poll warbler remains in his tropical home during February and March, and is not seen in southern Florida until about April 20.

By the first of May he arrives in central Missouri, which the robins left 60 days earlier, and yet he reaches northwestern Alaska only 10 days later than the robins. The latters' 90-day schedule has been shortened by the warbler to 30 days.

The black-poll warbler furnishes a striking example of speed acceleration during the latter part of migration. As indicated on the map of his migration route (page 348), between April 20 and April 30 he goes from central Missouri to central Iowa, a distance of 300 miles, or an average of 30 miles a day. The next 10 days the rate rises to 100 miles a day, while during the last few days of migration a velocity of 300 miles a day is attained.

In contrast, notice the dates, distances, and speeds indicated for the cliff swallow on its migration-route map (page 349). The swallow must strike out for the north very early, since by March 10 it is already 2,500 miles from the winter home, and yet is averaging only 25 miles a day for the next 20 days, while it is rounding the western end of the Gulf of Mexico. It more than doubles this rate while passing up the Mississippi and Ohio rivers. The crossing of the Alleghany Mountains comes next, and there are only 200 miles of progress to show for the 10 days of migration. By this time spring has really come east of the Alleghanies, and the swallow travels 60 miles a day to its summer home in Nova Scotia.

It is to be noted that the swallow, like the robin and the black-poll warbler, works up to high rates of speed when it is traveling on a diagonal, and that except during the 10 days spent in crossing the mountains, each 10 days' travel covers approximately five degrees of latitude.

SOME NARROW MIGRATION ROUTES

The accompanying illustration of the range of the scarlet tanager (page 363) is given to show the narrowness of the migration route as compared with the width of the summer and winter homes. This tanager nests from New Brunswick to Saskatchewan, a region extending over 1,900 miles of longitude. The Mississippi Valley birds go south and the New England birds southeast, until they all leave the United States along 800 miles of Gulf coast from Texas to Florida. The migration lines continue to converge until in southern Central America they are not more than a hundred miles apart. Arrived in South America for the winter, the birds scatter over a district about one-half the area of the summer home, with an extreme east-and-west range of about 700 miles.

THE BOBOLINKS ARE SEEKING NEW ROUTES

The migration route of the bobolink (page 365) shows a similar though not so decided a contraction at its narrowest part. The summer home extends from Cape Breton Island to Saskatchewan, 2,300 miles, and the migration lines converge toward the rice fields of the South, the objective point of all bobolinks, no matter where they nest.

Having gorged themselves to repletion, they press on toward their Brazilian winter abode; but the South Carolina and Georgia birds take a course almost at right angles to that chosen by the scarlet tanagers from those States, and strike out directly across the West Indies for South America. In this part of their journey their migration path contracts to an east-and-west breadth of about 800 miles, while a very large proportion of the birds restrict themselves to the eastern 400 miles of this route. In South America, the region occupied during the winter has about one-fifth the breadth and one-third the area of the breeding range.

The bobolinks of New England have witnessed great numerical changes, or evolutions. When the white man arrived on the scene, nearly all of New England was covered by primeval forest and bobolink meadows were scarce. As the forest gave place to hay-fields, the bobolinks promptly took advantage of their chance and their numbers increased steadily until the maximum was reached some 40 years

THE MIGRATION ROUTE OF THE BOBOLINK IS CHANGING (SEE PAGE 364)

ago. Then the newly invented mowing machine and the horsepower hay-rake began to destroy thousands of nests and caused a marked diminution in the bobolink census.

The case of the bobolink is a fitting close to this article, because it is revealing to us at the present time the manner of evolution of a new migration route. By nature a lover of damp meadows, it was formerly cut off from the western United States by the intervening arid region. But with the advent of irrigation and the bringing of large areas under cultivation, little colonies of nesting bobolinks are beginning to appear here and there almost to the Pacific. Some of them are shown by dots on the accompanying map, and the probability is that the not distant future will see a large increase in these trans-Rocky Mountain bobolinks.

XUM

SAND DUNES AND SUNKEN DATE GARDENS OF THE OUED SOUF

THE COUNTRY OF THE ANT MEN

By Thomas H. Kearney

ONE of the most remarkable portions of the Sahara Desert is the region known as the Erg. It is a wilderness of great ridges of sand that extends from southeastern Algeria far into the hinterland of Tripoli. In the northern part of the Erg, about midway between the Jerid district of Tunis* and the Oued Rirh Valley in the Algerian Sahara, the oases of the Souf lie hidden among dunes that are almost mountainous in size.

Although less than 200 miles from the termini of three railways—Biskra and Tebessa in Algeria and Gafsa in Tunis—the Souf country is so difficult of access that it is rarely visited by Europeans. I had heard much of its marvels from the natives of the Jerid, and it was therefore with a feeling of keen anticipation that I started thither from Nefta one November morning (see map, p. 377).

Our road led first across the westernmost prolongation of the salt flat called the Chott el Jerid, which is about 70 feet below sea-level. Near the bank the salt lay like a powdery rime of hoar-frost on the dark-colored mud. As we proceeded across the Chott it became a continuous crust, like ice on a pond, but so thin and transparent that we could plainly see the muddy bottom. Gradually the crust thickened and the mud was visible only where the hoofs of camels and donkeys had broken through. In places the salt had been forced up, as if a mole had made his runways beneath, into a network of low ridges.

Striking displays of mirage were seen here. The rocky hills on the south side of the great salt pond seemed much nearer and higher than was really the case, and their jagged peaks appeared to give place to flat-topped buttes. The center of the Chott assumed the likeness of a lake of blue water, with graceful clusters of palms along its shore.

Climbing the steep bank that marks the western border of this depression, we saw before us a seemingly endless expanse of nearly level country, dotted with hummocks about waist high. Each little mound was crowned by a spiny bush of "retam" or by other gray shrubs of the desert. Among them in every direction wound faintly marked bridle paths. How the Souafa guide found his way through this maze I could not guess. Yet find it he did, rarely hesitating as to which was the right road. He seemed to be guided more by instinct than by reason, for he was generally in a state of half stupor, caused by the hashish which he smoked constantly.

We rode all day through this dreary region and supped with the clean desert sand for a table. The guide made beds of the coarse grass known as "drinn"—the principal food of camels in the Sahara—upon which we spread our blankets. The night became so cold that after the first few hours I could sleep but little. There was compensation, however, in the view of the glittering African sky, uninterrupted from the zenith all around to the horizon, that one could enjoy to the utmost while lying on the ground.

By 10 o'clock the following morning we were engaged in a labyrinth of dunes, laboring up one side of a sand-hill and sliding down the other with our donkeys sinking nearly to their bellies at every step, then following one of the long trough-like stretches of hard ground that lay between the ridges of sand before starting up the next slope.

The last few miles of our journey was an excessively toilsome climbing and descending of enormous dunes, some of which must have been 500 feet high from base to summit. Nowhere could we see the smallest leaf or twig, for this sand

* Se "The Date Gardens of the Jerid," by Thomas H. Kearney in National Geographic Magazine, July, 1910.

XUM

"OFTEN THE BORDERING RIDGES WERE SO HIGH THAT EVEN THE TOPS OF THE PALMS COULD NOT BE SEEN UNTIL WE REACHED THE VERY BRINK OF THE BASIN"

The slightest puff of air suffices to start a little cloud of light sand curling from their crests. After every violent windstorm the natives must toil for days to carry the sand out of their gardens, "a veritable labor of Sisyphus" (see page 369).

is so constantly in motion that even the hardy desert grasses, with their long, creeping rootstocks and ability to resist burial, are unable to find a foothold. A striking bit of evidence of the mobility of the sand was an apparently fresh wagon track, which ran sharp and distinct for several rods, then stopped abruptly at the base of a good-sized dune, to reappear beyond it.

As the day waned these giant sandhills assumed an unearthly beauty, the dense shadows among them emphasizing their contours and contrasting most vividly with the tawny yellow of their sunlit flanks. The surface of the sand was delicately modeled with wind ripples, so that at a little distance it looked like watered silk.

We reached El Oued, the capital of the Souf, shortly after sunset. At the little hotel, kept by a Marseillais, European guests are so few and far between that, turning back three or four pages of the register, I found the name of Professor Massart, the Belgian botanist, who had visited the region six years before.

My first excursion next day was to a high point at the northeast corner of the

town, where the view shown on page 366 was had. Except for the houses of El Oued behind us, nothing could be seen in every direction but great ridges of pure sand absolutely bare of vegetation.* Here and there among the dunes the clustered heads of palms projected, looking almost black by contrast with the prevailing pale buff of the sand.

Riding along the crests of the ridges, we could look down into the date gardens that nestle in the hollows among them. We found these sunken gardens —"ghitan" is the local name for them— to vary in size from mere pockets containing a dozen or a score of trees to large basins holding several hundred. Often the bordering ridges were so high that even the tops of the palms could not be seen until we reached the very brink of the basin.

The date gardens of the Souf are in constant danger of burial in the sand, for in that country the air is almost constantly in motion. During the winter the winds are generally from the northwest or northeast. In summer the prevailing wind comes from the southeast. It is not so hot as the occasional sirocco that blows from the south, but is usually more violent and carries more sand. With their steep slopes and knife-edge summits, the dunes that border the basins are peculiarly liable to wind erosion. The slightest puff of air suffices to start a little cloud of fine sand curling from their crests. In gardens that have been abandoned for a few years the trunks of the palms are sometimes entirely submerged and only the tufts of leaves protrude.

The blowing is checked in some degree by fences made of palm leaves or low walls of gypsum rock along the crests of the dunes, but after every violent storm the natives are compelled to excavate anew the floors of their gardens. It is a veritable labor of Sisyphus. The sand is carried out in baskets on the backs of men who toil up the slopes of the dunes, sinking almost to their knees at every step.

In summer, when the fierce rays of the Saharan sun beat down relentlessly and the shade temperature sometimes reaches 120° F., as much as possible of this back-breaking work is done at night. During the period when the dates are ripening especially strenuous efforts must be made to keep the sand out, as the low-hanging fruit-clusters spoil quickly if buried. Souf dates fresh from the trees are usually liberally powdered with fine sand, and this coating must be brushed or washed off before they are fit for export. The natives themselves apparently have no objection to sand as a condiment with their dates.

The gardens have a very different appearance from those of most Algerian and Tunisian oases. The palms are widely spaced, so that sunlight reaches the ground almost everywhere, and the clean sandy floor of the basins is patterned with the black shadows of the palm leaves, flecked with patches of bright light. The palms are remarkable for the great thickness of their trunks, which sometimes reach three feet in diameter. Except for an occasional fig tree or pomegranate bush, no other plants are grown at the bottom of the ghitans.

A peculiarity of the Souf region which at once strikes the traveler familiar with the ordinary oases is the absence of surface water. There are no springs nor streams, no canals and ditches for irrigation and drainage. The rain that falls at rare intervals is quickly sucked up, leaving the surface of the sand as dry as ever an hour or two afterward. But in the hollows among the dunes the water-table is usually only a few feet below the surface of the soil. The country is believed to be underlain by a subterranean river; hence its name "Oued" Souf.

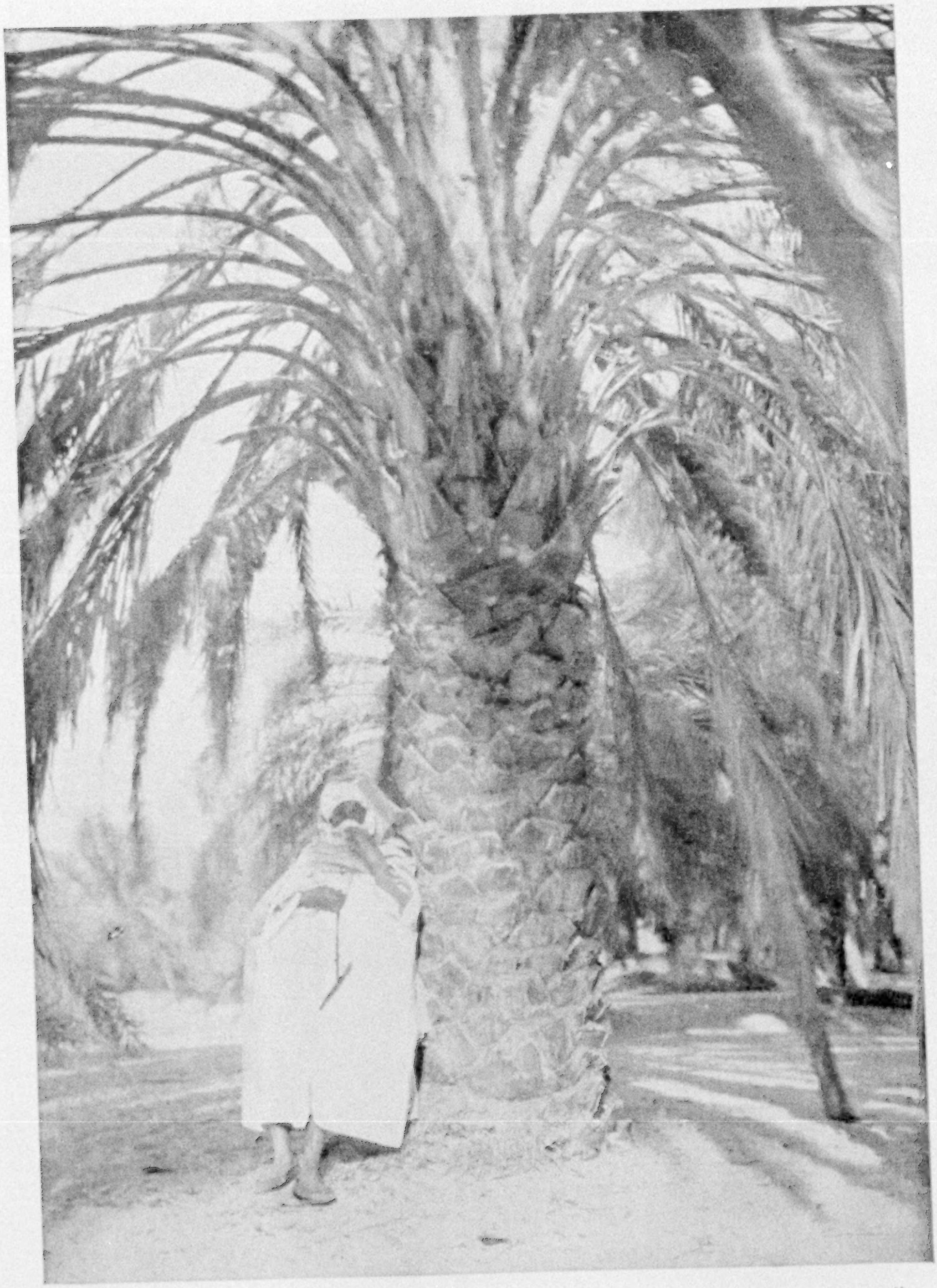
In planting a date garden in this region, the first step is to sink a well in order to ascertain the depth to ground water at the bottom of the basin. It then remains only to deepen the basin so much as is needful to make the dis-

* Professor Massart could discover only eight species of flowering plants growing wild in the Oued Souf.

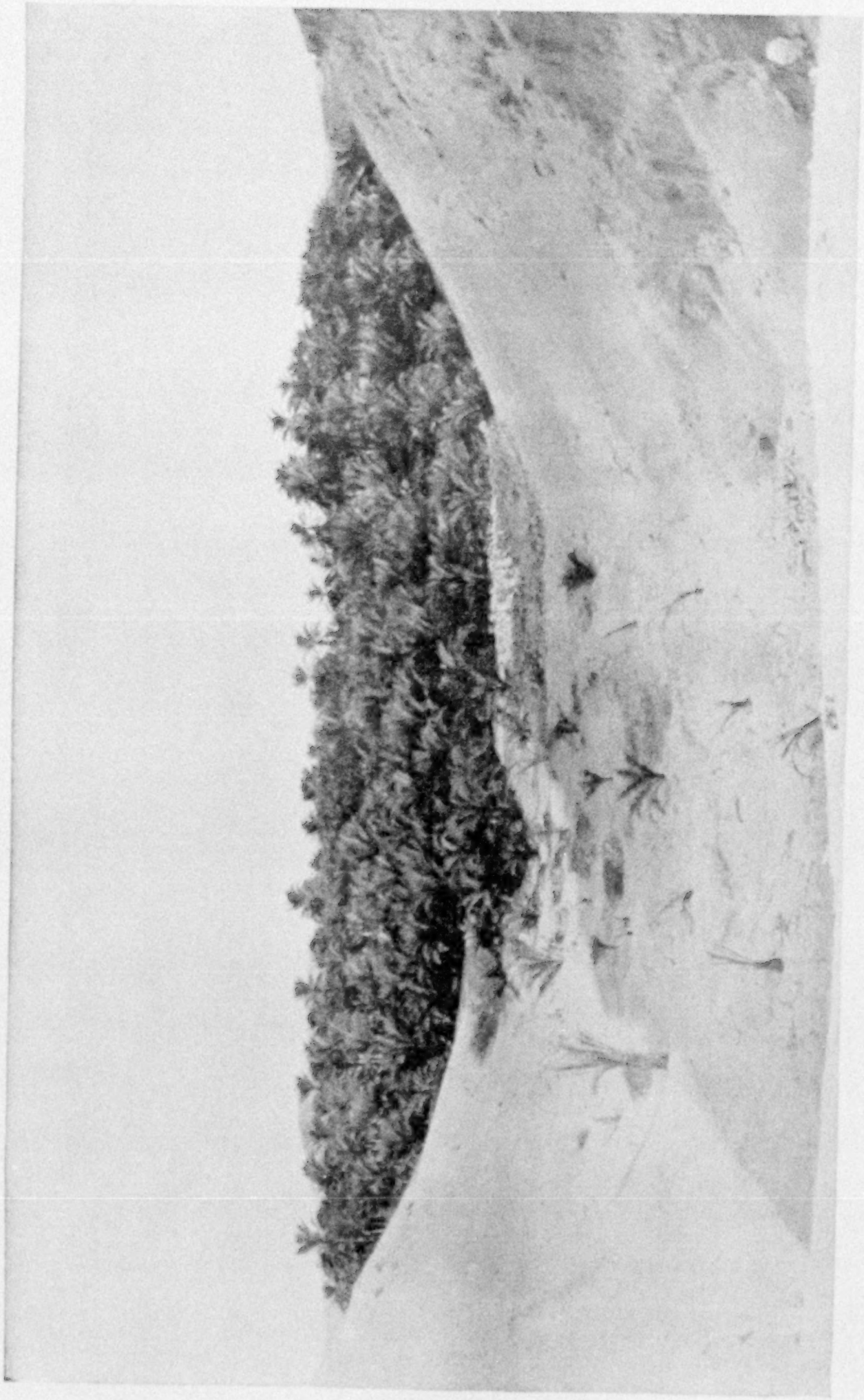
"DURING THE PERIOD WHEN THE DATES ARE RIPENING, STRENUOUS EFFORTS MUST BE MADE TO KEEP THE SAND OUT OF THE GARDENS, AS THE LOW-HANGING CLUSTERS SPOIL QUICKLY IF BURIED"

tance from the bottoms of the individual holes in which the offshoots are planted to permanently wet soil not greater than two or three feet. With an occasional watering by hand during the first summer, the roots of the young palms soon find their way to the underground moisture, and thereafter no irrigation is required.

The soil of the gardens being a pure



"THE PALMS ARE REMARKABLE FOR THE GREAT THICKNESS OF THEIR TRUNKS"



RECENTLY PLANTED EXTENSION OF A DATE GARDEN, MADE BY SCOOPING AWAY SAND ENOUGH TO PERMIT THE ROOTS OF THE OFFSHOOTS TO QUICKLY REACH GROUND WATER (SEE PAGES 369-370)

sand and nearly always dry on the surface, the conditions are not favorable for the germination of date seeds. Consequently one misses the seedling palms bearing fruits of every description, with which the neglected gardens and waste places in other oases are crowded. This explains the fact that there are apparently no varieties of dates peculiar to the Oued Souf. Even offshoots are produced sparingly, and the natives must perforce journey to distant oases in search of them.

The dates grown in the sunken gardens of the Souf are highly reputed throughout the Sahara, being considered especially superior in sweetness and in keeping quality. This is doubtless due to the peculiar conditions under which they ripen, the sandy sides of the basins acting as reflectors, which increase the direct heat and light of the sun's rays. There being no surface moisture, the atmospheric humidity in the gardens is undoubtedly much lower than in the swamp-like oases of the Jerid and the Oued Rirh, and this also must tend to improve the quality of the fruit. Certain it is that dates ripen early in the Souf. None remained on the trees at the time of my visit (November 22-26), while in the Jerid the harvest continued that year until January. The Deglet Noor dates produced in the Oued Souf are carried by caravan to Biskra, whence they are shipped to Europe.

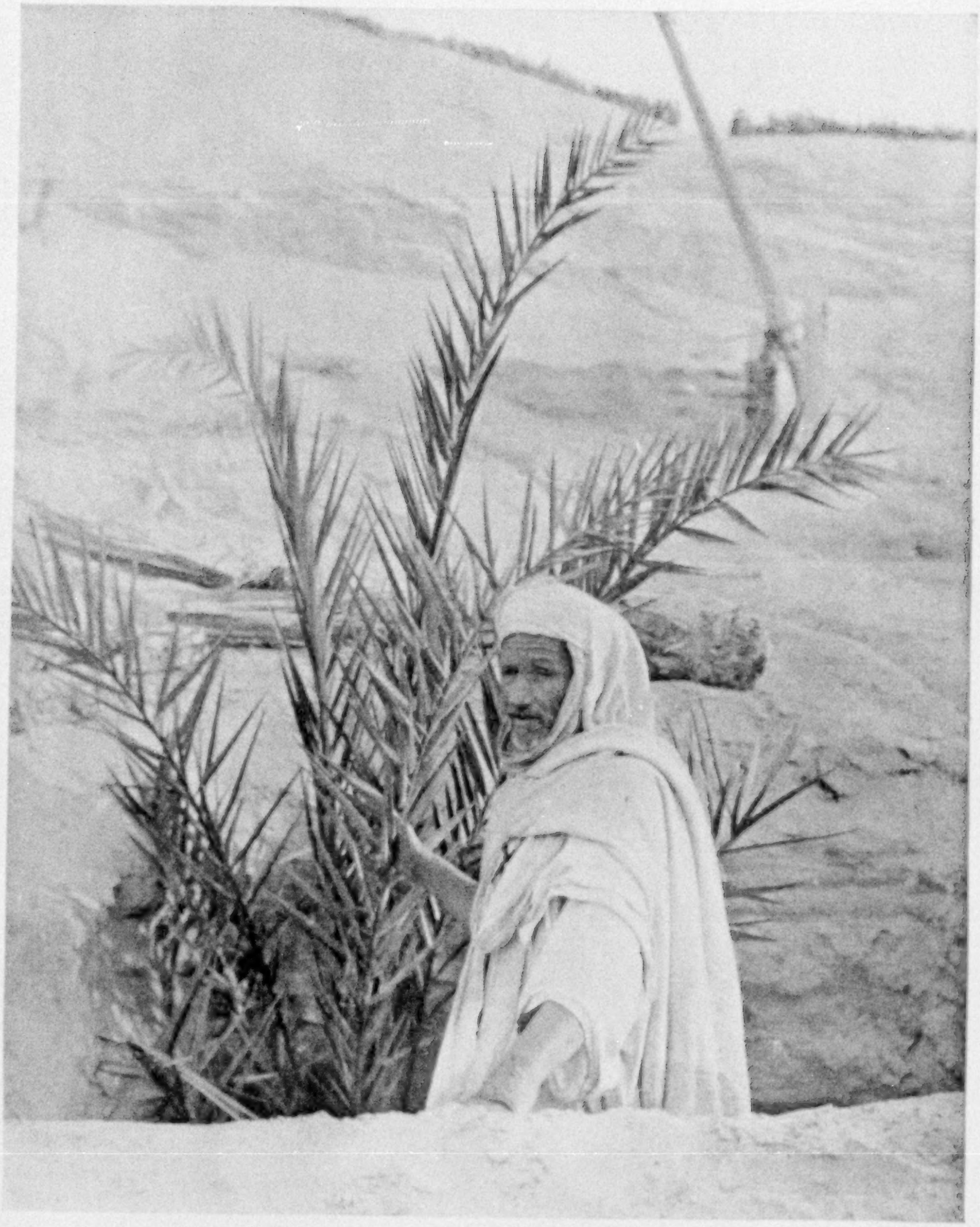
On terraces constructed in the slopes of the bordering dunes, a few feet above the floor of the basins, are located the shallow wells which furnish water for starting the palms and for irrigating the little vegetable gardens, which are also usually situated on these terraces. The water is lifted by means of a contrivance very similar to the Egyptian "shadoof." It consists of a basket daubed with pitch, hung on the end of a palm trunk that is supported between upright posts. A stone fastened to the larger end of the pole serves as a counterpoise.

Since the soil of their country is a nearly pure sand which will not stand up when wet, the Soufis are compelled to resort to plaster made from a gypseous rock in constructing the dikes by which the irrigation water is retained on their plats of vegetables. Conduits made of the same material lead the water to the plats, and plugs of wool are used to dam the tiny stream at the point where it is to be diverted. The lining of the wells is also made of this cement, and it is used in constructing the mounds with which the weakened bases of old date palms are reinforced. The rock from which this plaster is made outcrops here and there among the dunes. It frequently occurs in large clusters of crystals known as "Souf roses." The small kilns in which the rock is burned are a characteristic feature of the roadsides in some parts of the country.

The human ants who have wrought out this highly specialized system of horticulture in the teeth of such tremendous obstacles are, it scarcely need be said, far more industrious and energetic than most of the natives of northern Africa. The Soufis not only find time for the heavy labor needed to protect their date gardens, but tend flocks of sheep and goats and manage besides a great part of the caravan business in the northern Sahara. There appears to be a tribal distinction between the more sedentary gardeners and the widely traveled conductors of caravans. The camels of the Souf are reputed to be the largest and strongest in all the great desert.

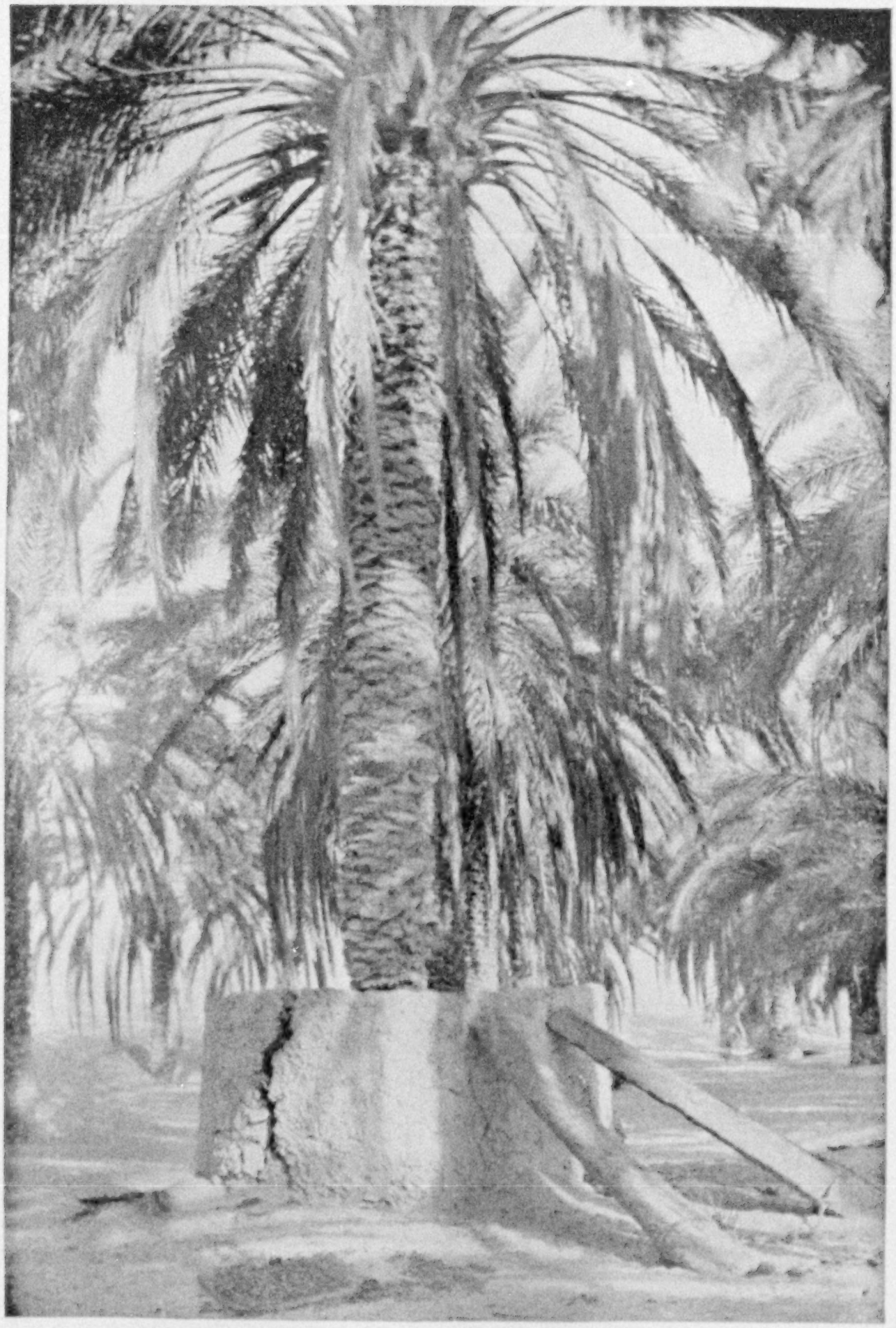
As a rule, the Soufis, like their date palms, are strong and healthy looking, being favored by their climate, which is a good one despite the intense summer heat. The absence of surface water is probably the chief reason for the healthfulness of the country. The Souf is said to be free from mosquitoes, which make life a burden during many months of the year in the Jerid and the Oued Rirh. Malaria, the scourge of the irrigated oases, is apparently unknown here.

The absence of clay suitable for making the sun-baked brick of which houses are constructed elsewhere in the Sahara has put another tax upon the ingenuity

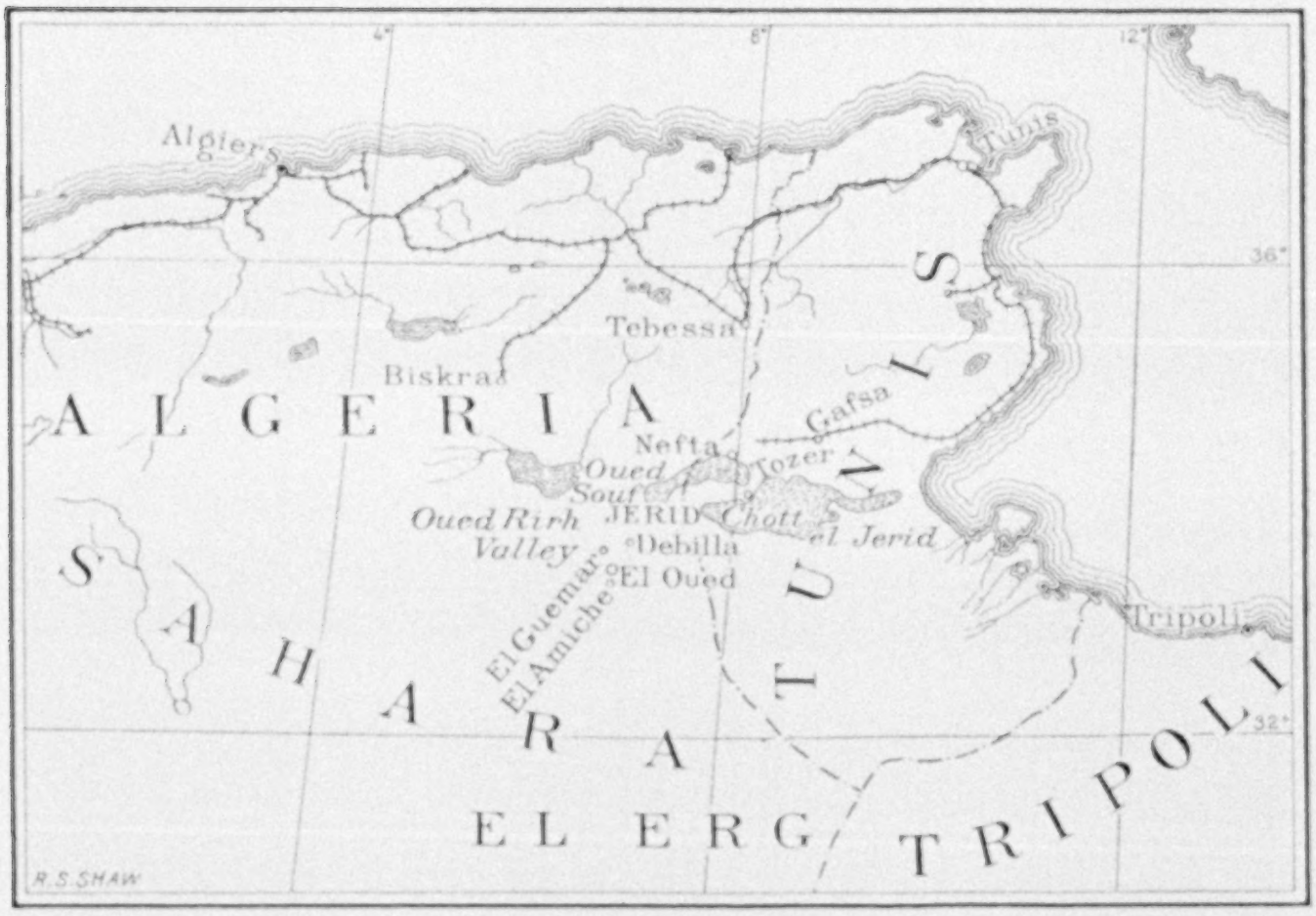


PLANTING DATE PALMS IN HOLES TWO OR THREE FEET DEEP (SEE PAGE 369)

ONE OF THE EXTENSIVELY GROWN DATE VARIETIES OF THE OUED SOUF: NOTE THE VERY HANDSOME FOLIAGE OF THIS VARIETY



THE WEAKENED BASES OF OLD PALMS ARE SUPPORTED BY CIRCULAR MOUNDS FACED WITH CEMENT



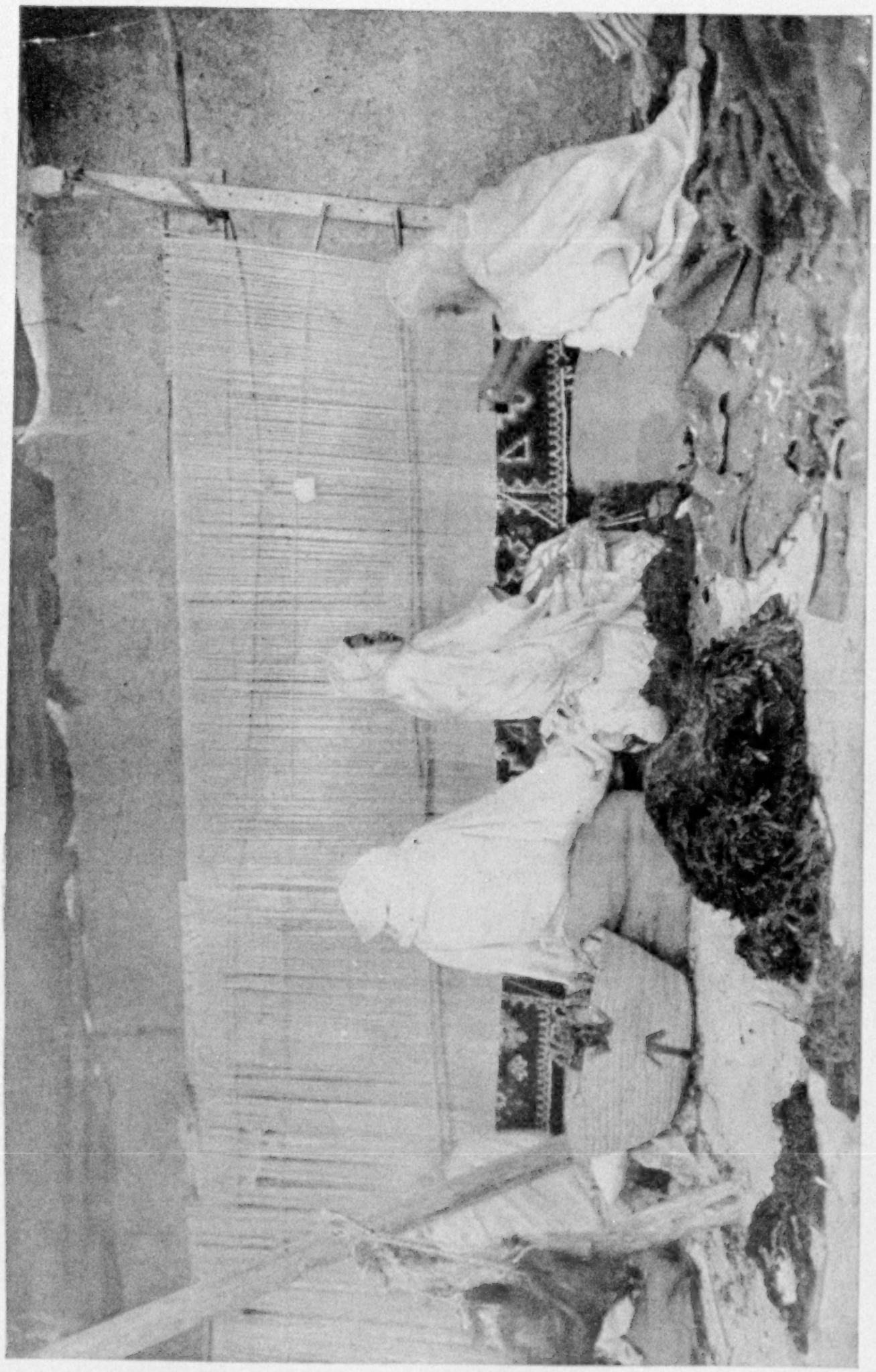
OUTLINE MAP OF THE SOUF COUNTRY

of this interesting race. For building material they are forced to depend upon the gypseous rock of the country and upon cement manufactured from it. Even the roofs are made of this substance, for in the Oued Souf date palms are too precious to be sacrificed for building purposes. Either because the material has not sufficient cohesion or because the architectural skill of the people is not equal to the construction of large arches, the roofs consist of rows of small flattened cupolas. Consequently, when seen from a distance, a village of the Souf looks like a cluster of drab-colored bee-hives.

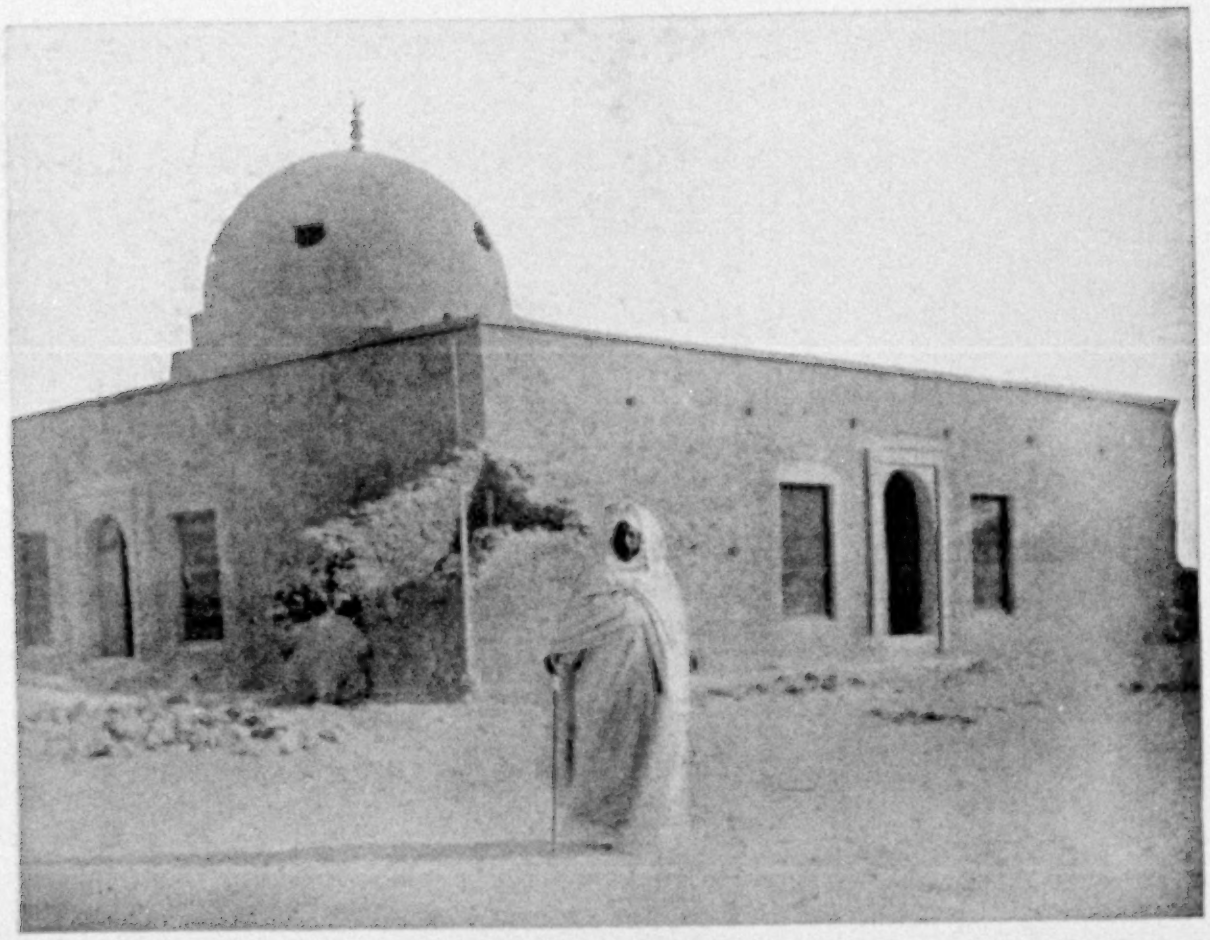
A feature of the towns which brings them into sharp contrast with the usual Arab village is their extraordinary cleanliness. Sand, the great purifier, is continually drifting among the houses, hiding with its mantle of charity the refuse that offends the traveler's senses in most North African towns.

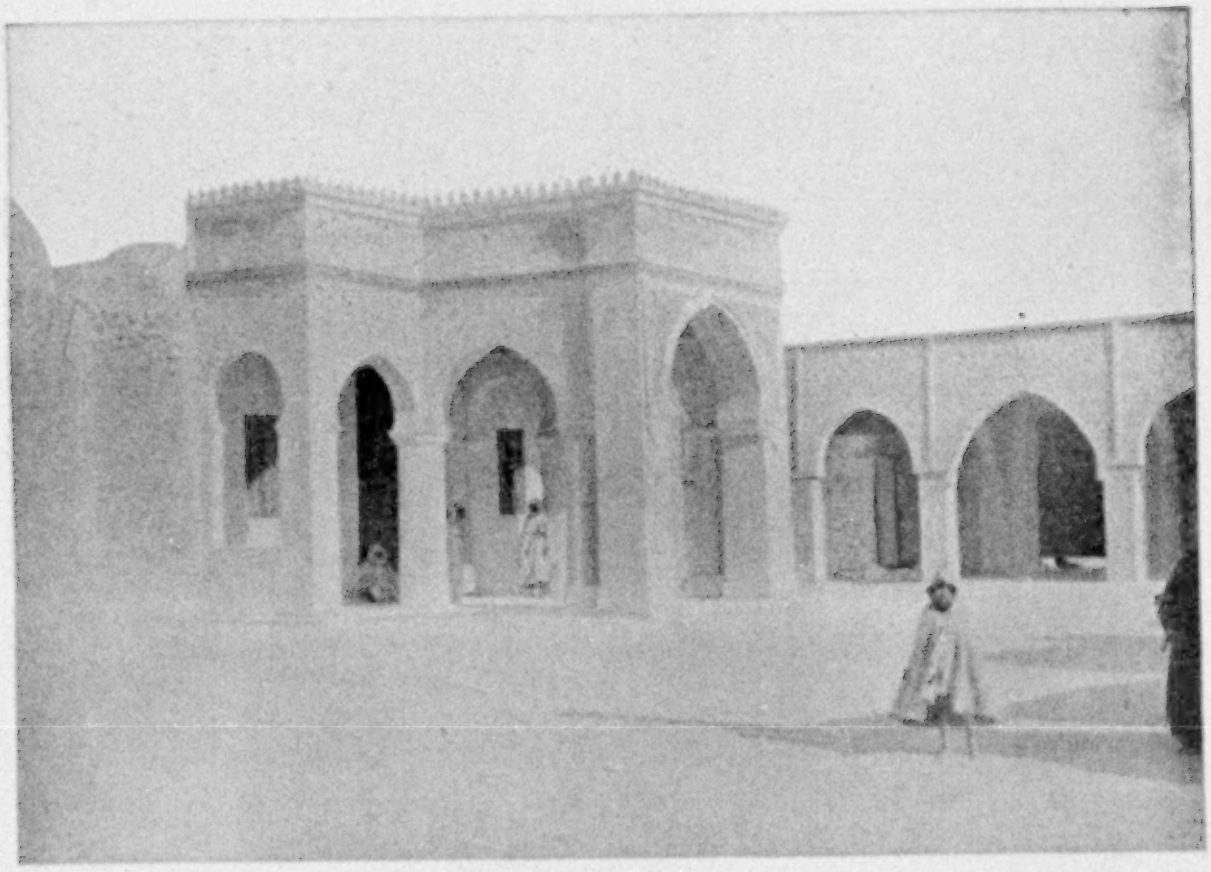
El Oued, the capital, numbers about 5,000 people, or one-fifth of the total population of the region. It contains few curiosities. Apart from a large mosque, the most conspicuous structures are steel wind-mills of American manufacture. The names of the streets are announced by neat blue-and-white placards at the corners. One notices that celebrated African explorers have been commemorated in such names as "Rue Duveyrier," "Place Flatters," etc. The district is administered by French army officers of the "Bureau Indigène," under whose supervision two caïds mete out justice to the natives.

One of the most interesting episodes of my sojourn in the Oued Souf was a visit to El Amiche, a village situated a few miles south of El Oued. Here I was entertained at luncheon by the marabout, a highly venerated leader of the "Khadraya" sect of Mohammedans. The holy man served me with his own hands



"IN A SHED BEHIND THE MARABOUT'S HOUSE A NUMBER OF WEAVERS WERE SQUATTED BEFORE A LOOM OF PRIMITIVE CONSTRUCTION, MAKING A CARPET FOR THE MOSQUE"

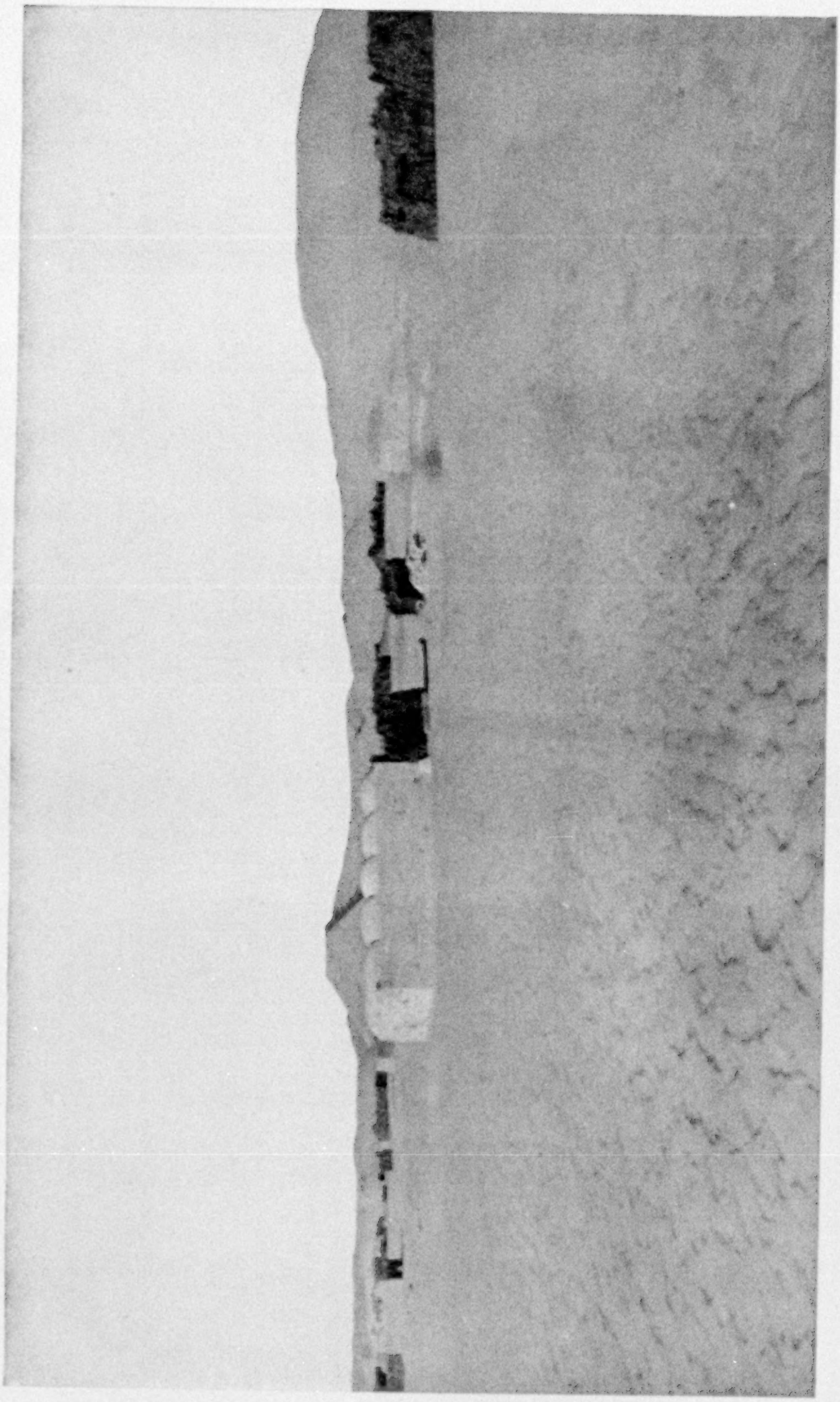




MARABOUT OF EL AMICHE, AND THE MOSQUE OF WHICH HE IS CUSTODIAN

HOUSE OF THE MARABOUT'S SON, EL GUEMAR

"The only dwelling of a native I have seen in the Sahara which could make any pretension to architectural merit"



"WHEN SEEN FROM A DISTANCE A VILLAGE OF THE SOUF LOOKS LIKE A CLUSTER OF DRAB-COLORED BEEHIVES"

and was so profuse with his complimentary speeches that I found it difficult, through the medium of my interpreter, to keep pace with him.

The meal was a plentiful one, better cooked and served than is customary among the natives. Nearly all the dishes were highly seasoned with red pepper. The *pièce de rèsistance* was, as usual, the celebrated cous-cous. The foundation of this dish was semolina, cooked so that every grain was dry and distinct. It was served in a wooden bowl with a ragout of meat, carrots, tomatoes, chick-peas, and dried apricots. The fried dishes were cooked with goat's fat, the provision of the Mohammedan law against eating swine's flesh preventing the use of ordinary lard. The bread, baked in round, hollow loaves with a very thin crust, was chiefly remarkable for its extreme toughness.

The repast ended with several cups of thick black Moorish coffee, boiled with sugar. A glass of lukewarm tea as a sort of "chaser" after each cup was an innovation which I did not particularly relish, but when one is entertained by a host of such sanctity, it is out of the question to refuse anything that is offered.

The marabout showed me with great pride a silver coffee service presented to him by a former governor general of Algeria. This was a reward for his services in bringing about the capture of the Touareg murderers of the Marquis de Morès, a young Frenchman who a few years before had made an ill-advised attempt to cross the Sahara with only a few Arab servants. I was told that in cases of this kind it is not unusual for the Algerian government to avail itself of the influence which the great marabouts possess among the wild tribes of the desert.

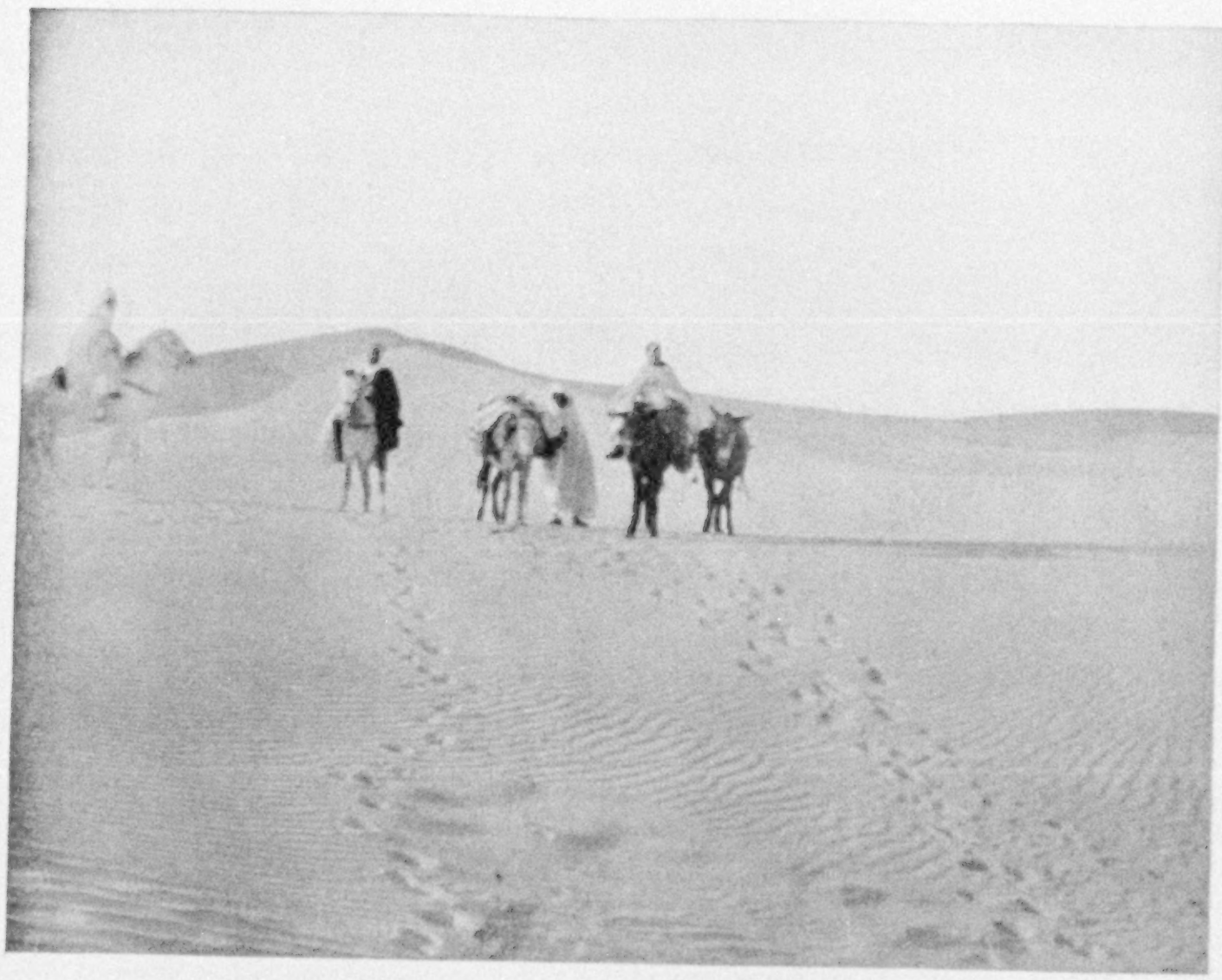
In a shed behind the marabout's house a number of weavers were squatting before a loom of primitive construction making a carpet for the near-by mosque, of which the marabout is custodian. The colors were gaudy and the pattern rude, yet not unpleasing.

Next day I rode to El Guemar, ten miles north of El Oued, and the second largest town in the Souf. It was market day at El Oued, and we passed crowds of men and boys driving laden camels and the sturdy little mouse-colored donkeys for which the country is noted. When I reached El Guemar I was immediately surrounded by a struggling, clamoring mob, whose behavior puzzled me until I learned that I had been mistaken for a purchasing agent of the Tunisian tobacco monopoly. Tobacco-growing is forbidden in Tunis and the government obtains its supplies largely in Algeria. We had noticed along the road as we came from El Oued many small irrigated patches of this crop.

There is another marabout at El Guemar, and my interpreter, who was always seized with a fit of devotion when in the neighborhood of one of these holy men, was anxious that I should make him a visit; but, remembering the rather formidable ceremonies of the day before, I declined the invitation and contented myself with a view of the house of the marabout's son. This had an attractive exterior and was the only dwelling of a native I have seen in the Sahara which could make any pretension to architectural merit.

The morning had been fine and sunny, but the weather was very disagreeable during our ride back to El Oued. The sky was overcast and a raw wind blew, at one moment filling our eyes with sand and the next driving gusts of cold rain into our faces. The woolen burnous which I had had made at Tozer a few days before proved very comfortable, although when riding I could never get the Arab trick of keeping its folds wrapped closely about the body while leaving both hands free to manage bridle and whip. The burnous is a very simple garment, with neither sleeves nor buttons. In fact it is hardly more than a blanket, gathered at one corner by means of a few curiously embroidered stitches, with a hole to pass the head through and a hood,

XUM



"THE LAST HOUR OF MY SOJOURN IN THE SOUF COUNTRY WAS SPENT AMONG THE TITANIC DUNES NEAR DEBILLA"

which is allowed to hang at the back when not needed as a head covering.

Following the advice of the French commandant at El Oued, we lessened the fatigue of the return journey to the Jerid by spending a night at Debilla, an outlying village of the Souf. The young sheikh of Debilla rode with us as far as his bailiwick. He was an exceptionally intelligent and fine-looking Arab. His costume, which did full justice to his handsome face and figure, consisted of a richly embroidered white silk haik and a snowy burnous of the finest wool. Mounted on a superb gray horse that seemed proudly conscious of the red and gilt of its trappings, he realized to the full the gallant cavalier of the desert who figures in the dreams of every school-boy reader of "The Talisman."

The last daylight hour of my sojourn in the Souf country was fittingly spent among the titanic dunes near Debilla—huge masses of pure sand, without stick or stone to mar their spotless surface. As the rays of the declining sun fell upon them, one could fancy that a sea of molten gold, lashed into fury by a hurricane, had been cooled and fixed before the billows subsided.

RECENT GEOGRAPHIC ADVANCES, ESPECIALLY IN AFRICA

By Major General A. W. Greely, U. S. Army

WITH the reasonable assurance that the Arctic Pole is surrounded by a deep, extended sea, and with the knowledge that its Antarctic antipodes is in practically the center of the greatest land-mass of the world, it is obvious that man's persistent activity has outlined the general contours of all seas and continents. It thus follows that the heroic phase of geographic exploration has passed for all time, and that men eager for recognition turned some time since their energies to researches which promise either scientific results or commercial advantages.

In considering geographic advances, it is pertinent, and perhaps not devoid of popular interest, to present the base-maps of modern geography. As novel to many, there is (p. 388) reproduced a map of the world, drawn from a catalogue of J. W. Hiersemann, Leipzig. It is from Francesco Berlinghieri's Italian Geography, *Geographia in terza rima et lingua toscana*, Florence, 1478-'80, probably the second oldest of printed atlases. Berlinghieri naturally continued Ptolemy's error of undercalculating by one-third the distance between Europe and the east coast of Asia, and it may well be that this very map from a home atlas encouraged Columbus in believing the unexplored distance to be navigable.

As illustrative of the vast advances in geography during the following half century after the voyage of Columbus, there is also reproduced the new world-chart, *Universale Novo*, from the work of Pietro Andrea Mattiolo, *La Geografia di Claudio Ptolemeo Alesandrino* (with additions by Sebastian Munster and Jacob Gastaldo), Venice, 1548. Although Magellan had circumnavigated the world, Asia, Europe, and America (as yet unnamed) are herein charted as one unbroken land-mass. These maps of four centuries since furnish means for interesting comparisons with the surface of the world as we know it today (p. 389).

DISCOVERIES OF NEW LANDS

Man's success in the explorative conquest of the world is forcibly illustrated by the statement in a leading editorial that the year 1910 had been quite devoid of actual geographic achievement, there being one notable addition only—the Antarctic discoveries of Charcot. Of all men, Dr. Charcot takes a broader view of geographic science and is unwilling to measure its progress by mere additions of hitherto unknown surface areas of the earth, welcome as such knowledge is.

It will be remembered that Charcot in 1905 by discovery extended Palmer (or Graham) Land southwest to Loubet Land, 67° south, 71° west. His expedition of 1909-'10 was specially fitted for scientific research in botany, geology, glaciology, hydrology, magnetism, meteorology, and oceanography. Reaching in the *Pourquoi Pas?* his farthest point of 1905, Charcot successfully worked his ship through the ice to the southwest, and, reaching the hitherto unvisited Adelaide Island (Biscoe, 1832), accurately located its position. It is an island 70 miles long, not a mere islet of less than 10 miles, as previously reported. Continuing his running survey, Charcot found that Alexander I Land (Bellingshausen, 1821) is a continuation of Palmer Land, indented by a vast gulf along whose glacier-lined shores he traced 120 miles of new land. Altogether the new discoveries extend the local southing from 65° 30′ to 68° 45′ south, and traverse a previously unknown sea between 104° and 128° west, save only as intersected at 108° west by Cook in 1774. Charcot's discoveries have an especially important

bearing on the boundary of the great continent Antarctica, whose now recognized existence is due to the discoveries of Palmer, Bellingshausen, Wilkes, D'Urville, Ross, Enderby, Drygalski, Bruce, Nordenskiöld, Scott, Charcot, and Shackleton. Of Charcot's work M. Charles Rabot justly says, "It is one of the most fruitful in scientific results of any recent polar expedition not having the pole as its object."

EXPLORATIONS OF THE TWENTIETH CENTURY

The most important subjects of geographic research and exploration pertain, however, to the habitable earth and bear practically on their utilitarian relations to the activities of mankind. In his scholarly annual address to the American Historical Association, its president, Prof. F. J. Turner, while pointing out that the geographer is an allied laborer in historical study, added: "Historians must deal with the connection of geography with industrial growth, politics, and government. . . . Changing geographic factors . . . must be considered if we would understand the bearing of legislation and policy." This statement conforms to the generally accepted idea that the science of geography covers not alone the physical aspects of the earth—animal, mineral, and vegetable—but more particularly includes the interrelations of man with his material environment.

IMPORTANT FIELDS OF ADVANCE

It is pertinent to determine the phases and locate the fields towards which research is most persistently devoted. An examination of the publications for a year of the two great foreign societies, the *Royal Geographical Society* and the *Société de Géographie*, disclose that in the former one-third of the leading articles and in the latter one-half pertained to Africa. The character and extent of geographic work of importance are most clearly indicated by the proceedings of the Société de Géographie, which, without derogating from the special merits of other societies, may be said to take the broadest and most laudable activity in fostering and recognizing geographic research. In 1910 it awarded no less than 27 prizes, consisting largely of medals, though often supplemented by money grants. Nine awards were made for work in Africa, six relative to Asia, three to France, three to the Western Hemisphere, three for technical work, two to oceanography, and one for Antarctica. Nineteen awards were for researches pertaining to human relations, or bearing on natural resources, while one only was connected with the discovery of new lands. In its award to Shackleton the committee, recognizing the evolution of modern research, said pertinently: "Far from being simply a wonderful tour-de-force of physical vigor, it was especially and above all fruitful in scientific results of the highest importance." With Gallic liberality, two awards were made to aliens—Sir Ernest Shackleton and Mr. Bailey Willis (of the National Geographic Society).

EARLY AFRICAN CARTOGRAPHY

Two of the African maps of Mattiolo, Venice, 1548, are herewith reproduced. *Africæ, Tabula IIII*, shows Africa as depicted by Ptolemy in the second century. It will recall to many the legends and tales of childhood through Caphos (Cepheus), the mythical king of Ethiopia; the man-killing elephants of the equatorial interior, and the mystical Mountains of the Moon (*Lunæ Montes*), which for so many centuries figured as the long-sought sources of the historic Nile. This second-century map of Ptolemy, it should be added, was nearer correct as to the Nile and the adjacent mountains than were the standard maps at the beginning of the nineteenth century (p. 390).

Africa, Nova Tabula, represents the continent after the recent circumnavigation by da Gama (p. 391). The new map enlarges the drainage basin of the Nile to include the greater part of the continent, introduced a score of mythical cities, and eliminates the beloved Mountains of the Moon. And thus stood, as

Photo from "The Heart of the Antarctic," by E. H. Shackleton

A SEAL DESTINED FOR THE LARDER: IN THE ANTARCTICS

a whole, geographical knowledge of the Dark Continent for three centuries, advancing only some 60 years since.

AFRICA OF THE TWENTIETH CENTURY

As bearing on geographic work, it should be borne in mind that Africa has been divided between European powers. The most important spheres of control, direct and indirect, in areas and in population are approximately as follows: France (including Morocco), area 45 per cent, population 24 per cent; Great Britain (including Egypt), 35 and 39 per cent; Germany, 9 and 12 per cent, and Belgium, 9 and 16 per cent. Actuated by political considerations and stimulated by the spirit of commercial expansion, the colonizing countries have pursued their researches so efficiently that today Africa is better known and more accurately charted than are extended areas of Asia and South America.

African explorations have been the outcome of private enterprise for commercial exploitation, under the auspices of geographic societies for the advancement of scientific knowledge, and through official parties for the development of the country. Prolific in results have been the labors of the many boundary commissions for deliminating the separate regions under European control. In Africa by wise prevision are prevented the international disputes similar to those which neglected boundaries have entailed so often on the continents of America.

FRENCH RESEARCHES

The most striking results are those accomplished by the unequalled energy of France in her steady advances towards the assimilation and domination of the northwestern half of the continent of Africa. Their commissions have not alone explored the unknown regions, but they have thoroughly investigated the commercial possibilities of the immense territories under their control. Their reports bear on the productivity of the

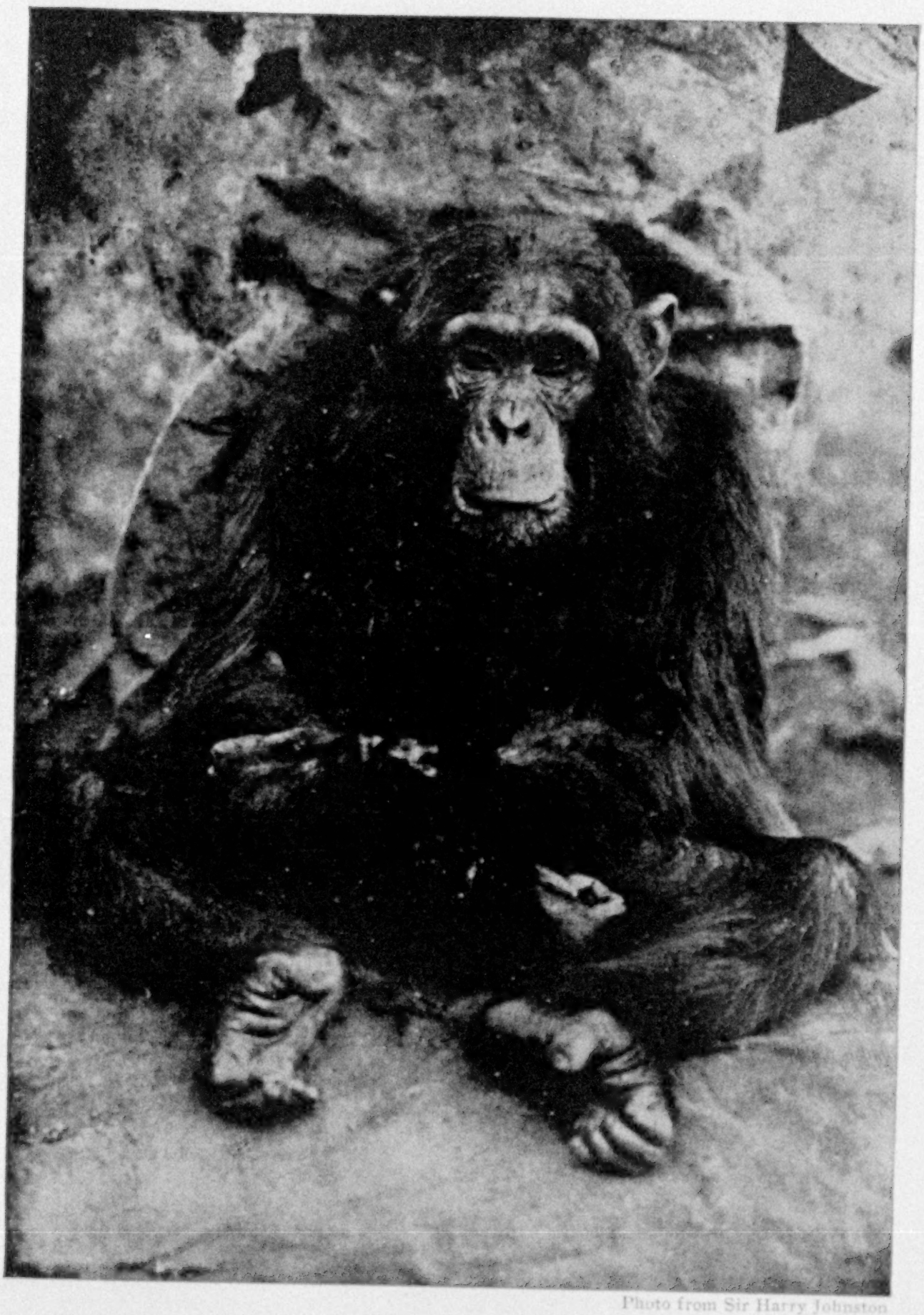


Photo from Sir Harry Johnston

A MALE CHIMPANZEE IN THE UGANDA

soil, the suitability of the climate, the existence and accessibility of forestal wealth, the presence and probable extent of mineral veins, and on transportation methods by road, river, or by rail. Equally valuable are their data on the social habits, tribal characteristics, centralizing conditions, and governmental methods of the millions of natives, on whose activities and stimulated wants must eventually depend the commercial development of Africa.

The French army has contributed largely to these valuable researches, and the views of its trained and selected officers are well expressed by General Lebon, who said of Africa: "Geography becomes a fairy godmother whose mission is to reveal to man for his highest good infinite and hitherto unutilized riches." The struggle of the army to insure safe travel across the Sahara was most bitter, as well as its work in Morocco, and there were in 1908-1909 in North Africa more than a hundred fights, with a French loss of several hundred in killed and wounded. Peace and order now prevail; the occupancy of the desert palm groves controls the nomads. Today at no point in the vast French Sudan is there seen more than a single company for police duty.

It should be known that the regions in Africa controlled by France exceed in extent by more than 50 per cent the area of the United States, and it is obvious that only the more important of its many recent explorations can be even mentioned in this brief summary.

THE SAHARA REGION

Though comparatively unfertile, the great Saharan Desert vastly influences the surrounding regions. France controls it by oasis guards, selected scouts of experience, called *méharistes*, well mounted on camels. This service, at an expense of $600,000 a year, is true economy. Under earlier conditions the Bilma trans-Saharan route was plundered to the amount of a million and a half dollars yearly, besides the enslavement of the natives there captured.

Great portions of the desert (the Saharan-Sudan region) have been charted through the geodetical work of French officers. Captain Cortier, the chief, states that a vast region 9 degrees in longitude and 12 degrees in latitude is sufficiently watered to produce grain (mil) from grass wherever the soil is not sand-invaded. He relates that the Touaregs habitually open the anthills and take therefrom the reserves of grain accumulated by the ants.

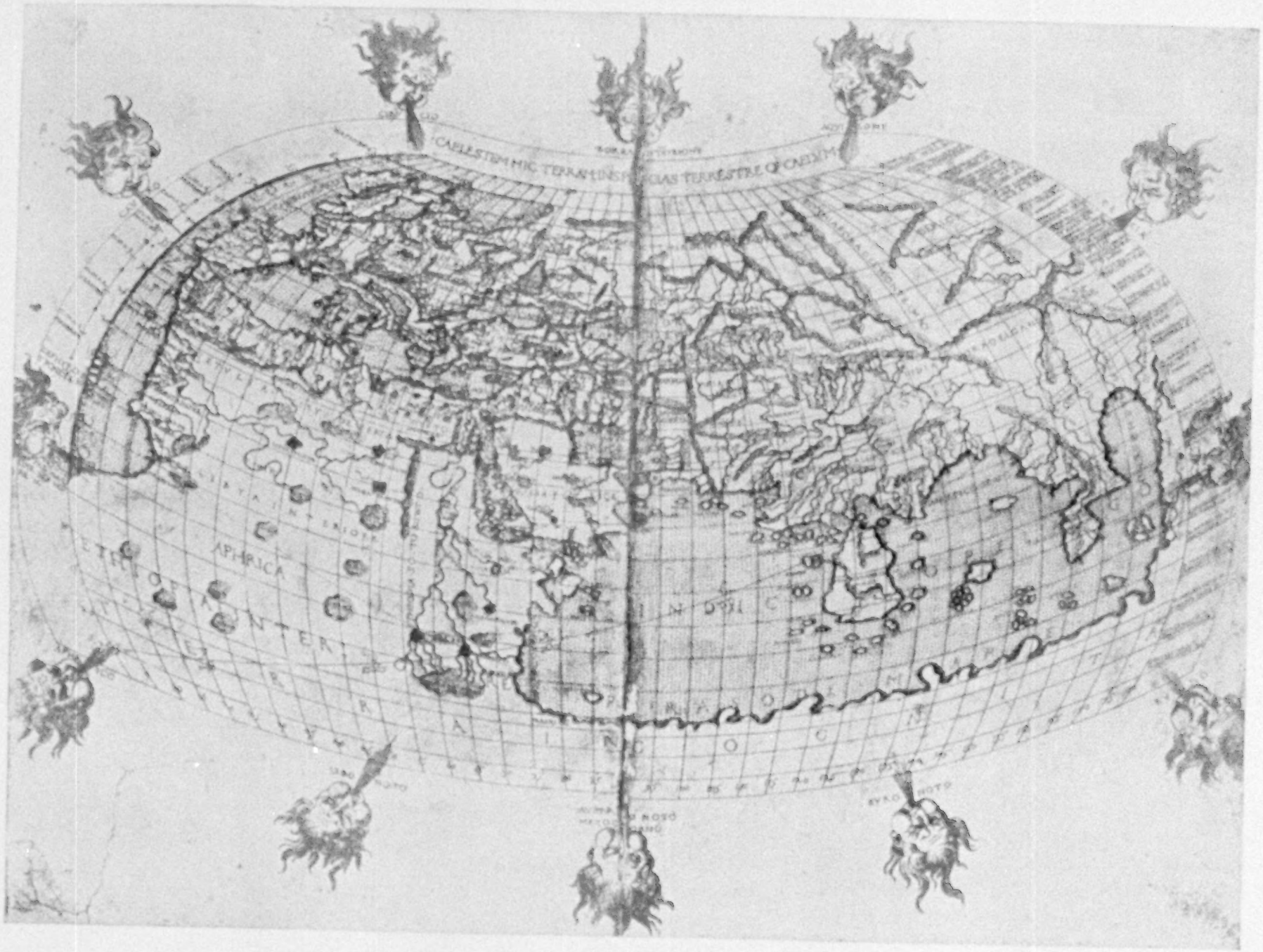
His description of Kauouer modifies our ideas of a Saharan oasis. Its 100,000 palm trees furnish subsistence for a dozen straggling villages, with their small flocks and scant crops of grain and vegetables. Adjacent desert routes are filled with long trains of slow-paced, heavily laden camels carrying the annual exports of the oasis—25,000 loads of salt and 5,000 of dates.

FRENCH KONGO

In connection with the Kongo-Kamerum boundary, Captain Périquet explored 500 miles of unknown routes, of which 300 were through dense woods. Railway surveys now progressing from Libreville to the Sanga River are through great forests, which are being actively exploited, the natives being tractable instead of hostile, as before reported. These surveys disclosed a high, rolling plateau, the lofty Crystal Mountains of that region being mythical.

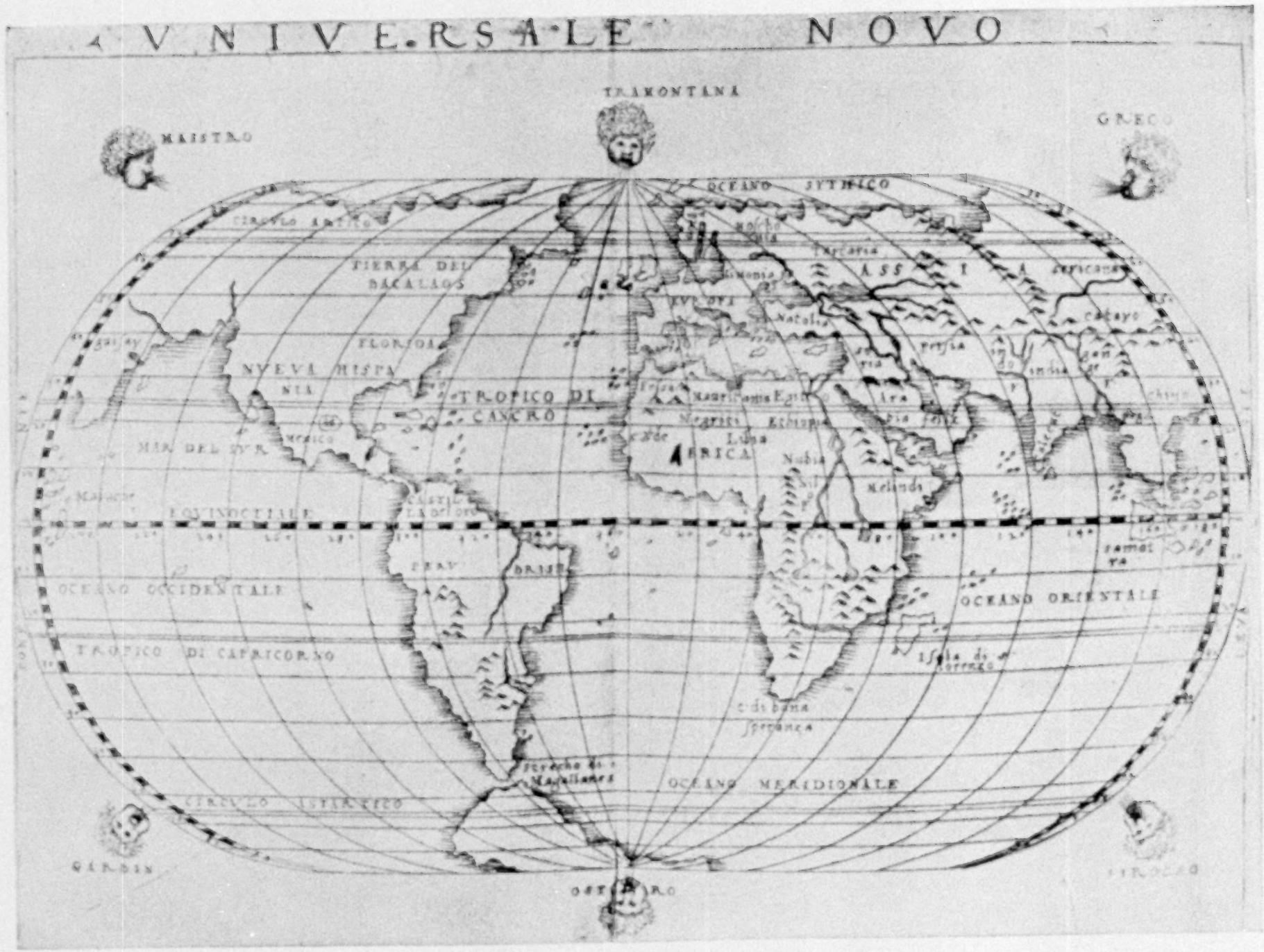
MOROCCO

Nominally independent and practically unknown, this country is gradually developing under the activity and influence of France, to whose sphere of influence it naturally trends by association and propinquity. Since 1904 M. Louis Gentil has annually investigated unknown areas of Morocco, studying its hydrology, locating its mineral wealth, and examining its forestal and agricultural zones. His maps are the first to adequately represent the physical conditions of the country. While mineral belts of prospective value are found, yet M. Gentil looks to the extremely fertile soil belts as insuring the prosperity of Morocco, fitted as they



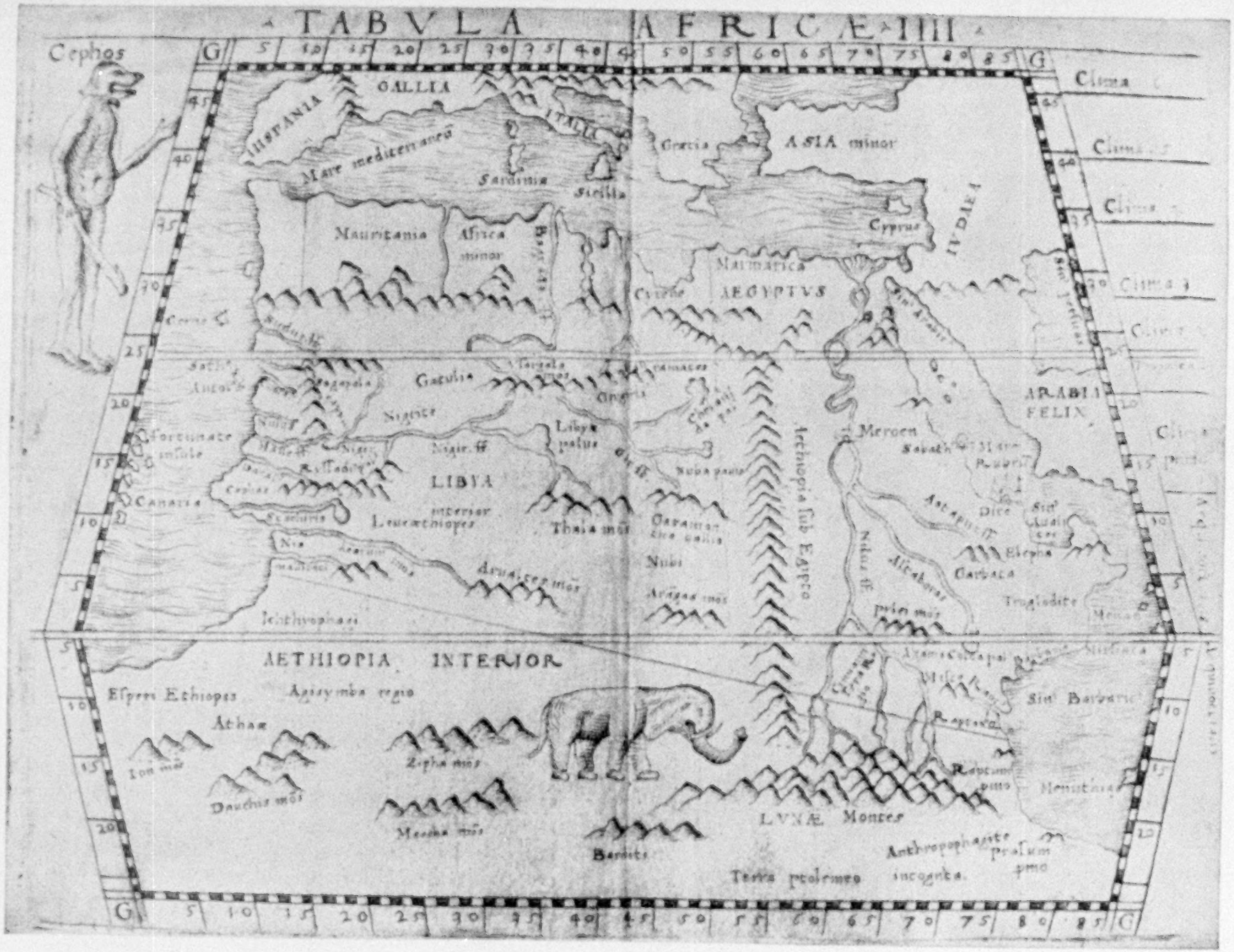
THE SECOND OLDEST MAP OF THE WORLD: BY BERLINGHIERI, BEFORE COLUMBUS (SEE PAGE 383)

Probably this is the map which set Columbus to work. It was printed in Florence, near enough for him to see it



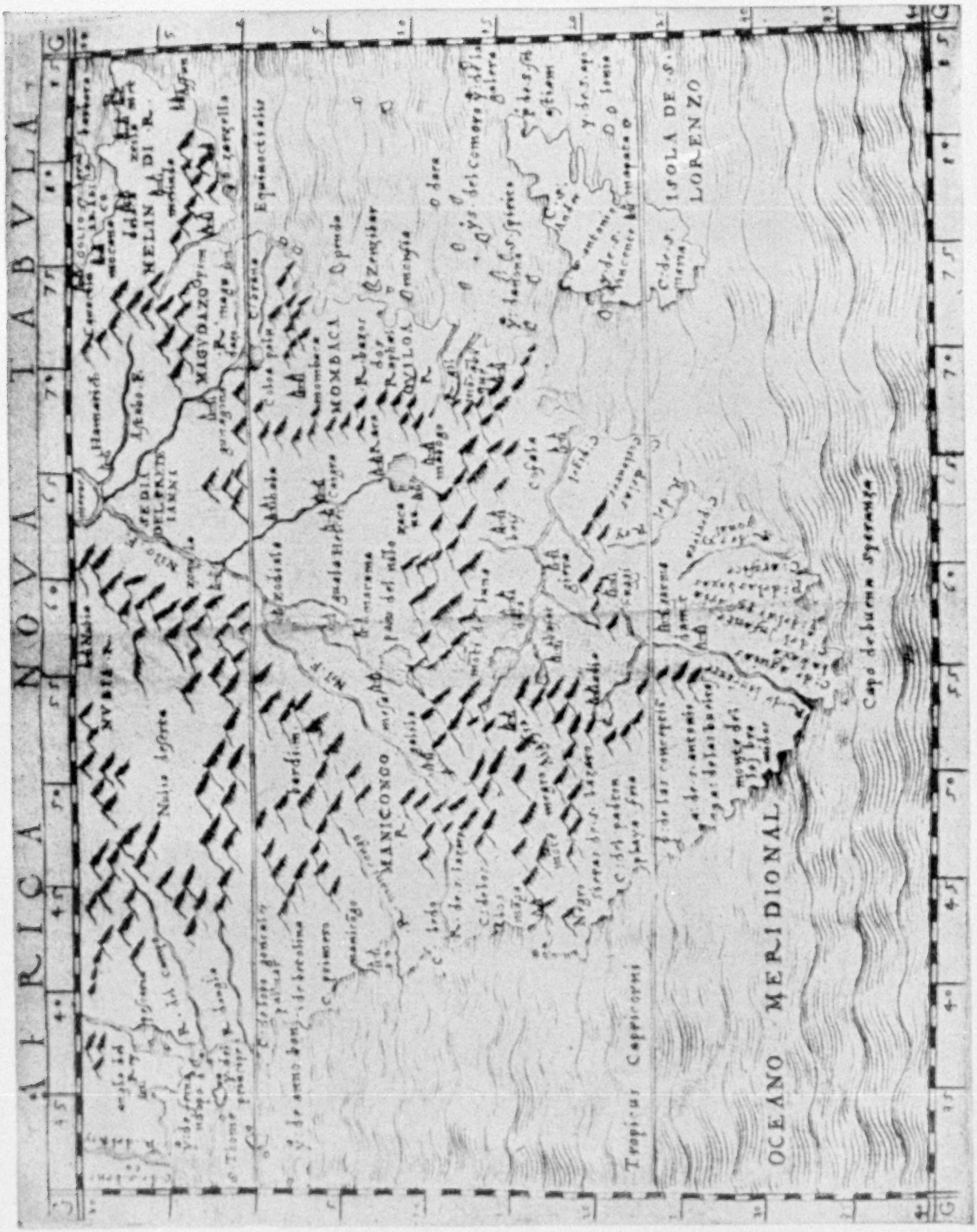
THE WORLD-CHART: BY MATTIOLO, 1548

Although Magellan had circumnavigated the world 26 years before, Asia, Europe, and America were still charted as one unbroken land-mass (see page 383)



MAP OF AFRICA, AS DESCRIBED BY PTOLEMY IN THE SECOND CENTURY: BY MATTIOLO: VENICE, 1548

This map was more nearly correct as to the Nile and adjacent mountains than were the standard maps of Africa, published at the beginning of the nineteenth century (see page 384)



FROM THE NEW MAP OF AFRICA, WITH DA GAMMA'S DISCOVERIES, 1498; BY MATTIOLO, 1548 (SEE PAGE 384)

are for forestal and agricultural products.

COLONIES OF THE WEST COAST

The watershed of the Niger and the adjoining Atlantic areas have largely engaged attention through their fertility and trade possibilities. The railway from Guinea to Conakry, owned by the West French African government, has been built, thus connecting the upper Niger with the ocean. Its average cost per mile was $32,000, and 5 million dollars were paid the natives for construction work. The availability of local labor is shown by the 12,000 natives working on the road in 1909. Its economic value to the country is evidenced by the steadily increasing freight, which has raised the net income per mile from $200 in 1906 to $1,240 in 1909.

M. Hubert explored geologically the Siguiri and adjacent regions through 60 square degrees, and maps now cover geologically 400,000 square kilometers. M. Aug. Chevalier, 1908-1910, investigated the Atlantic coast colonies, the flora, agricultural factors, and forestal resources of Guinea receiving close attention. The Ivory Coast proves especially rich in rubber along the Liberian boundary. In Dahomey a region mapped as a marsh proves to be a dry, well-wooded plain. The explorations of Captain Gross disclose the existence on the Ivory Coast of valuable forests of an area of about 8 million hectares and the existence therein of 58 kinds of useful woods. There is no tribal organization, but the government is by family. Labor is available under just and humane conditions, so that the forests can be economically exploited. The dreaded local climate proves susceptible to hygienic improvement. Fourn's surveys in Dahomey, Ringenbach's investigation of the sleeping sickness, Gironcourt's explorations of the bend of the Niger, and Zeltner's work in the Sudan are worthy of note, but space lacks.

THE CHAD REGION

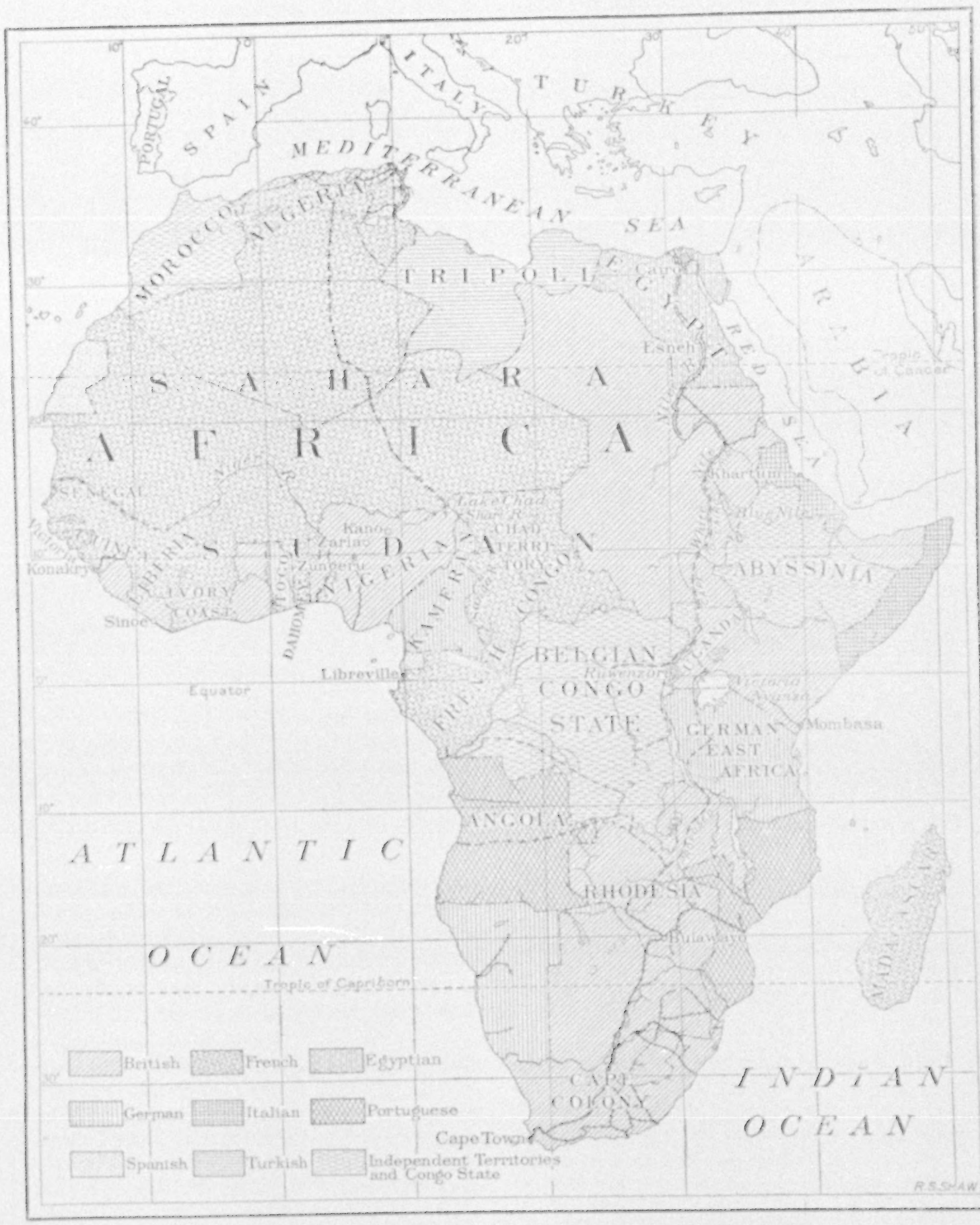
Of all narratives of missions, that of Capt. Jean Tilho, 1907-'09, in surveying the Niger-Chad boundary most appeals to the imagination through the vast and strange country it concerns. The region was opened by France in 1901, when her troops defeated the cruel negro tyrant, Rabah, the pest of the terror-stricken tribes. The country is an interior drainage basin, like our own Salt Lake Valley, of enormous extent—about three times the area of France. French methods have brought about order and prosperity. 50 *méharistes* today keeping peace among the various tribes along a border of several hundred miles.

Scientific explorations disclosing its resources, the Chad basin was amicably divided between England, France, and Germany. Tilho's boundary work was supplemented by extended researches between 12° to 17° north, and from 0° to 15° east (Paris). His survey included 400 astronomical positions and involved 25,000 miles travel. Valuable collections and observations were made in ethnology, magnetism, geology, and natural history.

WOOD WHICH IS LIGHTER THAN CORK

Especially interesting are the strange a m b a c h (*Herminiera elaphioxylon*) forests, growing in the waters of Lake Chad to 25 feet in height and 12 inches in diameter. This curious tropical tree grows only in water of moderate depth and so rapidly that it attains its full height in two years. The wood when dried is the lightest in the world, its density being only 40 per cent that of cork.

The most interesting feature is Lake Chad, in the center of this vast country, 2,000 miles distant from the ocean at Senegal and 1,200 miles from the Nile. While its maximum area of 10,000 square miles slightly exceeds that of Lake Erie, Chad is noted as being the shallowest lake of the world, its average depth being less than six feet. Fed by local rainfall and by three contributing streams (practically all water coming from Shari River), it loses about four feet annually by evaporation. In 1908 it was but one-fourth its maximum size, owing to suc-



OUTLINE MAP OF AFRICA, SHOWING POSSESSIONS OF EACH EUROPEAN POWER

OULED NAIL DANCING GIRLS

Photo by Bougault, Biskra. From "The Desert Gateway," by S. H. Leeder. Cassell & Co. Mr. Leeder's book is a fascinating and very sympathetic account of the Arab denizens of the great desert.

cessive years of drought. With rapid shrinking, fish perish by millions, cattle die, large game migrate, and tribes abandon the resultant salt marshes. Much of interest was gained relative to the natives, the Boudaman tribes to the south being agricultural and peaceful, while those to the north were pastoral and warlike.

BRITISH ACTIVITIES

Much the greater proportion of civilized peoples in Africa being under English control, British activities have naturally turned towards vital problems of finance, administration, and government. These questions assume extreme importance from their practical bearing on trade, commerce, and transportation, on which factors the future prosperity of Africa depends.

Though subordinated to these special activities, British explorations have, nevertheless, been fruitful, especially in connection with the eight boundary commissions, which have penetrated many unexplored regions, thus adding wealth of knowledge as to various tribes and their environment. Major Whitlock traced the Nigerian frontier 300 miles, surveying large areas under adverse conditions of hostility, which entailed severe losses in killed and wounded. Commander Whitehouse distinguished himself by an admirable survey of Victoria Nyanza and Ommanney through his astronomical work in Nigeria. In addition to the Uganda-Kongo surveys, Major Bright explored the Ruwenzori Mountains and measured through that

locality a section of the great meridian arc along 30° east.

Sir Harry Johnston, known in the NATIONAL GEOGRAPHIC MAGAZINE, has made studies of Uganda and around the equatorial lakes which stand scarcely second to any similar African researches. Fishbourne's surveys for the Uganda Railway were prolific in results, and Lieut. Boyd Alexander's transcontinental journey through the dense, tangled forests between the Niger and the Nile recalls the thrilling experiences of that great traveler, Stanley Africanus, 30 years earlier.

Of intense human interest are the ethnological studies of the many primitive peoples, whose individuality is vanishing under advancing civilization. Torday tells us of the people of the Kasai basin; of the Baboma women, with elaborately cicatrized faces, set off with brass neck-rings of 30 pounds weight; of the alert, skilled pigmy hunters; of industrious Misambu, where, wonder of wonders for Africa, every one works, carving, forging, weaving; and of the high forms of a pure African art apparent in the carvings and textile industries of these natives.

"UN SOU, M'SIEUR?" A BEAUTIFUL LITTLE BEGGAR GIRL

From "The Desert Gateway," by S. H. Leeder. Cassell & Co.

Perchance more fascinating are the researches of Talbot, sometime resident among the Ekoi of South Nigeria. A high-typed race, given to dance and woodland mysteries, they are survivals of Pan. The sacred Egbo (men's) and Nimm (women's) clubs are as inviolate to each sex, under penalty of death, as in the dawn of mythology. Among the sweet, quaint superstitions of the devoted Ekoi parents is one which forbids quarreling in a household of little children, who in their reincarnated state love gentle voices, smiling looks, and winning words.

CAPE TO CAIRO RAILROAD

Exploration and research induced trade and annexation, which in turn entailed colonization and governmental responsi-

A FALCONER

Photo by Bougault, Biskra. From "The Desert Gateway," by S. H. Leeder. Cassell & Co.

bilities. The formation of the South African Confederation and the occupation of Egypt have taxed British energy and resources to the utmost, and in their development transportation facilities were deemed of the highest importance.

The South African railway systems now aggregate 6,000 miles, with 2,000 miles more in prospect. Time and money are gradually transforming into reality the dream of a Cape to Cairo Railway. In operation last year from the Cape to Victoria Falls, 1,640 miles, it is built to

the German frontier. This section attains its maximum altitude of 4,850 feet near Bulawayo, having followed the crest of the watershed from a point a thousand miles to the south. From Cairo the railway extends to Rahab, 13° 8′ north, on the White Nile, 200 miles south of Khartum. With the Uganda Railway extending 600 miles inland from Mombasa, the east coast is well provided with modern transportation.

NORTH AND SOUTH NIGERIAS

Perhaps English advances have been proportionately greater in the Nigerias than elsewhere, their 13 millions of natives affording a broad field. They accept transition well, in general, and have been largely utilized in railway and other construction work. The road from Bocro, the navigable head of the Niger, to Zungeru and Zaira, is under extension to Kano. Steamboats on the Niger, well-kept roads, 4,000 miles of telegraph and telephone lines are transforming this part of central Africa. Technical schools and church missions are doing their part in modifying the habits of the people.

HYDROLOGICAL SURVEYS IN EGYPT

Important as have been the financial reforms and advantageous as are the transportation facilities afforded by British rule in Egypt, they yield in permanent value to the assured benefits of the surveys for conserving and extending the water supply of the watershed of the Nile. The regimen of the Blue and the White Nile has been thoroughly studied and the hydrological conditions accurately determined. As supplementary to the conservative methods now in operation, the accumulated data indicate that Egypt must turn to the annexed Sudan, with its millions of square miles of contributory watershed, for additional supplies. As is known, the great Assuan dam insures timely water supplies for the midsummer crops of lower Egypt, and its increased height has enlarged the irrigated sections by an area larger than that of the State of Rhode Island. An added regulating dam at Esna, upper Egypt, brings under cultivation waste land equal in area to Connecticut. The solution of the *sudd* (compact vegetation masses choking the river channels) problem in southern Sudan will largely increase the water from the equatorial lakes.

Captain Lyons, in Egypt, and Colonel Taylor, and successors, in the Sudan, have run a practically unbroken line of levels from the Mediterranean to Lake Victoria, 3,500 miles. Sudan surveys show the whole region on a scale of 1 : 250,000 with a fair accuracy.

KHARTUM AND THE SUDAN

Signs of changed conditions are nowhere more strikingly evident in the Sudan than in the transformation of the place of Gordon's murder. The collection of wretched huts, under dominion of a religious fanatic, has given way to a modern city, the center of peaceful justice, religious tolerance, thriving trade, and technical education. A city of 40,000, Khartum is the seat of government, a center of Coptic Christianity, is within nine days of London, and in touch with the world by railway, telegraph, and steamer. The demoralizing slave trade has forever vanished, peaceful trade conditions exist, and the environs, the most densely inhabited parts of the Sudan, are becoming prosperous through advanced opportunities and improvements in agriculture.

Its most distinctive advance was the establishment of Gordon Memorial College, the recognized center of modern education and scientific research for two millions of natives. It trains native youth for teaching or for the law, teaches the arts of surveying or engineering, and opens up a new world to the ambitious natives. American interest attaches to this college, owing to the endowment of its research laboratories by one of our well-known generous citizens, Henry S. Wellcome. Through the laboratories, pathological and economic researches have been made along the Nile and its tributaries for a thousand miles to the south of Khartum.

THE BELGIAN KONGO

The activities of Belgium have continued along lines of extreme commercial exploitation, which have given rise to commentaries, especially in connection with the main product, rubber. Whatever may have been past conditions, improvements are promised for the future in the way of opening up government land, equalizing taxes, and restricting application of punishments. Four hundred miles of railway and fleets of steamers afford transportation, which will soon be supplemented by suitable extensions by rail.

Perhaps the most extended research work has been in connection with Captain Newcombe's surveys for a railway from the upper Kongo to the watershed of the Nile. The railway levels from the Atlantic vary less than 60 feet at the intersection with the levels from the Indian Ocean.

GERMAN COLONIES

With national systematic methods, German officials have gathered data bearing on the resources of their colonies, which possibly lack financial aid from the government to the extent it has been granted by other nations. Diamond-mining and cotton-growing are recent developments of the colonies of the west coast.

It is interesting to note that the best atlas of Africa comes, not from a German source, whence it would be expected, but from an Italian, Signor Ghisleri.

German East Africa is a model German colony. Peace and order prevail, and education receives particular attention. The government has thousands of pupils in its schools, which are specially devoted to handicrafts. Many missionary societies devote their energies to the improvement of the people. It is doubtful if elsewhere in Africa there is such close attention to the individual native, and apparently with good results. There are many wide, well-kept roads, and though there has not been great railway development, the telegraph is largely installed.

LIBERIA

Americans are interested in Liberia, where after 90 years the hinterland is unknown. Light is thrown on it through the French-Liberian boundary commission of 1907. M. Moret (French) crossed Liberia from Gribo, 6° 21′ north, 15° west, to Sinoe. The hundred miles of unknown country thus traversed is covered with dense forests of rubber and palm. The few unwarlike, inactive natives eat only once a day, subsisting principally on palm nuts. Inland are rare patches of rice or beans, but toward the coast sugar-cane, bananas, etc., appear. Animals were seen but rarely.

The natives practice sorcery with African cruelty. They think that everything has a soul, and ascribe the singing of a lamp to its contentment with the oil.

Abyssinia as yet remains outside of any distinct European sphere, but time and circumstance will undoubtedly bring its warlike tribes to the normal African fate—exploitation by the white man.

AMERICAN POTASH FOR AMERICA

By Guy Elliott Mitchell

Of the United States Geological Survey

IN the great Stassfurt potash salt deposits Germany holds a world's monopoly of this precious fertilizing element. By a cleverly devised system of fixing quotas for all active mines and by imposing a heavy tax on all productions in excess of arbitrarily fixed quotas, the German Government has forced the United States to the full realization of this very embarrassing fact. The importance to the United States of developing an American potash industry to offset such a condition may be appreciated from the fact that last year we sent to Germany $12,000,000 for this mineral, peculiarly vital to every farmer in the land. Incidentally it may be remarked that the German deposits are practically inexhaustible, being estimated to contain, at the present rate of consumption, sufficient potash for the entire world for half a million years.

Tell the farmer that his supply of potash is endangered and it is like notifying the locomotive fireman that he will get no more coal, for potash is a necessary constituent of every bag of fertilizer which the farmer purchases when he drills in his wheat or rye or oats, when he plants his corn, his tobacco, or potatoes; in fact, every farm, fruit, and garden crop.

There are three elements necessary to plant growth, and potash is one of them. It is coequal with phosphorus and nitrogen, and every one of the 50 to 55 million sacks of fertilizer sold each year must carry a printed guarantee of the percentage of potash therein contained.

Germany is to some extent dependent upon our broad American acres for her food supply, but we are wholly dependent upon her for the continued production of a grain, fruit, and livestock surplus for export. Such a surplus is made possible only through soil stimulation by fertilizing.

The German attitude in this matter, while working an apparent immediate injury, cannot in reality prove other than a blessing in disguise to the United States. Without this agitation of the subject we would in all probability have continued for many years buying enormous quantities of potash salts, since the German deposits are almost inexhaustible. Now, however, our present helplessness has been demonstrated, and so we shall be compelled to develop our own latent potash resources until we are independent of any foreign supply.

EXPLORATIONS BY THE GEOLOGICAL SURVEY

It can be authoritatively stated that there is abundance of potash in the United States for present and future needs for fertilizing, for the manufacture of explosives, and for every other possible use.

Our potash possibilities will be developed along two distinct lines: exploration for potash salts and utilization of potash-rich rocks. It is believed that systematic searches for potash deposits, similar to those of Germany, will also lead to the discovery of beds of soda nitrate which may rival the great Chilean deposits. In 1910 our purchases of these two fertilizing materials—nitrate from Chile and potash from Germany—amounted to over $25,000,000. Within the next decade, at the present rate of increase in consumption, the figures will reach over $50,000,000 a year.

HOW THE POTASH MAY BE FOUND

Of great interest, therefore, are the preparations of the United States Geological Survey for the exploration for potash-salt deposits in the desert regions of the West. For this work Congress made a special appropriation of $20,000.

To understand how the geologists will search for potash, it will be well to consider the manner in which the German potash deposits were formed, bearing in mind the fact that ocean water contains considerable potash. Ochsenius, the

Photo from Illinois Agricultural Experiment Station

FIELD SHOWING THE VALUE OF POTASH TO THE FARMER

The soil is mucky and deficient in potash; the plat on the left has been enriched with potash, and yields a luxuriant crop. The center plat had no potash application, and the crop is scanty

German geologist, pictures, in the early ages of the world, an extensive and deep gulf or arm of the ocean, which later became land-locked, and the water of which gradually evaporated. The various substances in this concentrated sea water were deposited at the bottom of this lake, but the potash, being the most soluble, remained till the last, and was then laid down in a thick bed and deeply covered by strata of protective clay and other sediments.

Government geologists point to many sections in the West where the stratigraphic conditions are similar to those in Germany and most favorable for the existence of such potash beds. Potash is a constituent of all sea water, and the entire West was once covered by the ocean. As the land rose, it left immense salt-water lakes, containing billions of tons of potash, and these, during long geological periods, gradually evaporated. As a consequence the potash beds are there, beyond a doubt. The problem is to locate them.

The German potash mines are very deep, and it is expected that the American deposits also will be found far beneath the surface. To locate them will require deep drilling by means of rigs, such as are used in the oil fields. The search, however, will not be a hit-or-miss proposition. The Geological Survey will bring to bear its full knowledge of the geological structure of the arid region, and will carefully select the most promising of the areas known to have been covered by great prehistoric lakes.

For instance, in Utah there is an enormous ancient lake basin, of which the Great Salt Lake is the feeble remnant. This lake covered a large portion of the State of Utah, and its waters stood a thousand feet above the present shoreline of the Great Salt Lake. Its ancient beaches can be seen from the railroad train far up the mountain sides, above Salt Lake City. Another enormous lake, known geologically as Lake La Hontan, existed in Nevada. The potash contained in the waters of these great inland seas can only be estimated in countless millions of tons. Mono Lake, in California, a mere mill-pond by comparison, contains an estimated 10,000,000 tons of muriate of potash.

In some such prehistoric lake beds as those of Utah or Nevada, on the public lands, the Government geologists will decide upon sites for drilling, and if they do not strike potash soon it will be because the scope of their operations is necessarily restricted by the lack of money appropriated. It is hoped that success will crown the initial efforts. How the great find will be managed by the Government is an interesting question. The Government operates no mines; but having found the potash deposit it cannot well give it over to private interests to develop and probably monopolize. A great potash deposit, such as that of Germany, would have a potential value of billions of dollars. Probably the Government would have to retain title and lease the mines in the interest of the people.

MUCH POTASH IN GRANITE ROCK

Of scarcely less interest is the problem of the extraction of potash from rocks. Of the feldspathic rocks, including the granites, potash constitutes from 5 to 10 per cent and even higher percentages.

Among the igneous or volcanic rocks containing large amounts of potash, as described by W. C. Phalen,* are the glasses, of which the chief are obsidian, pumice, perlite, and pitchstone. In these rocks the potash may run as high as 5 or 6 per cent, or even considerably higher. The rhyolites are also rich in potash, commonly containing more than 5 per cent of potash, while a certain rhyolite from Silver Cliff, Colorado, has been shown to contain 8.38 per cent. The trachytes and phonolites are also well supplied with potash, some of these rocks containing nearly 8 per cent. The rocks of the Leucite Hills, Wyoming, described by Whitman Cross, of the United States Geological Survey, contain large percentages, certain of them carrying from 9.81 to 11.91 per cent of potash (K_2O). The greensand marls of New Jersey,

* Potash Salts; Their Uses and Occurrence, in the United States, 1910. U. S. Geological Survey.

VIEW OF SALT FLAT, CLAYTON VALLEY, NEVADA Photo by Walcott, U. S. Geological Survey

Many such prehistoric lake beds are scattered throughout the Great Basin region, whose depths may be sources of vast potash deposits

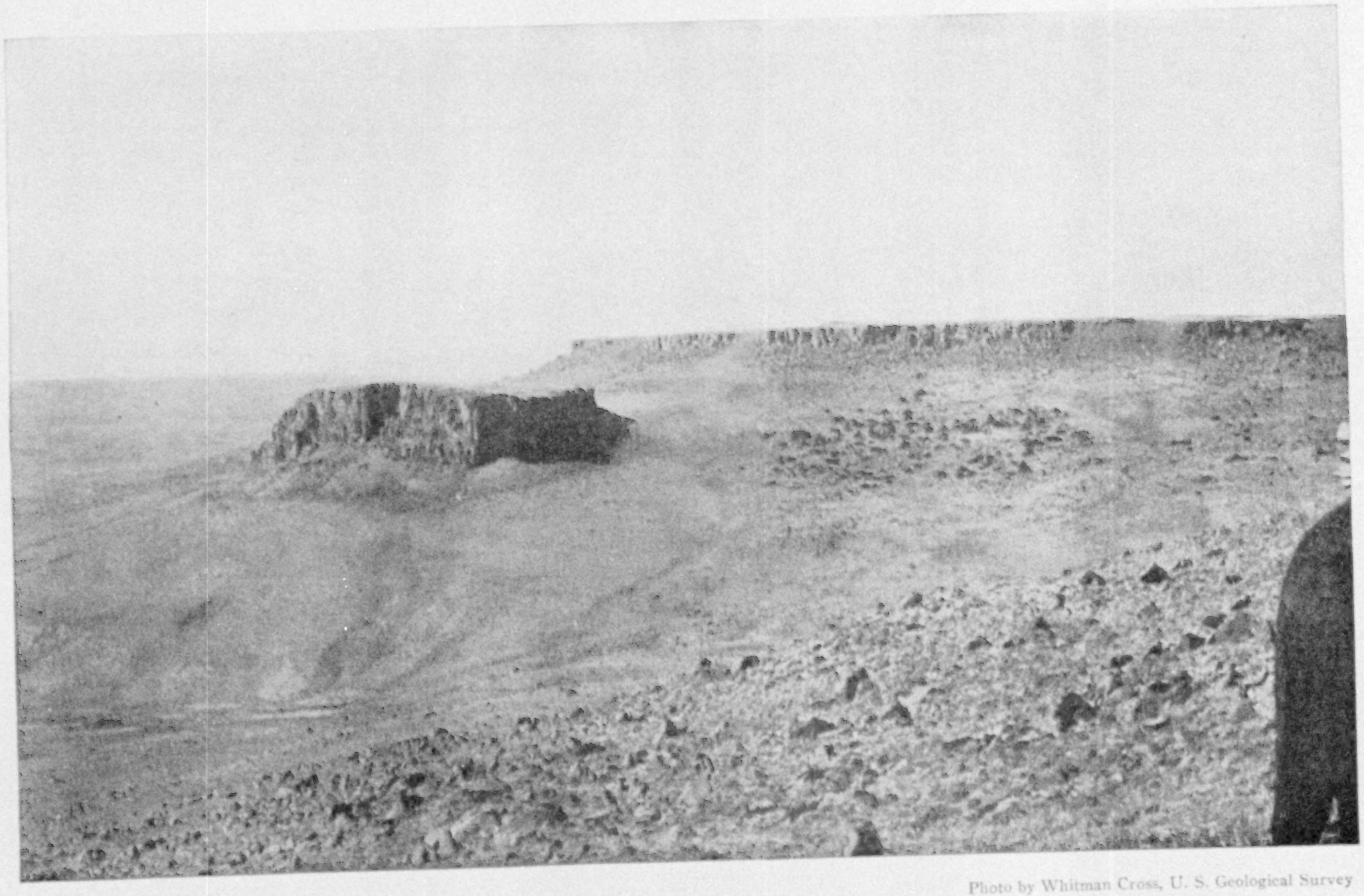


Photo by Whitman Cross, U. S. Geological Survey

NORTH TABLE MOUNTAIN, LEUCITE HILLS, WYOMING

This flat-topped mesa is capped by 50 to 100 feet of 8 to 11 per cent potash-bearing rock. The Leucite area covers at least 10 square miles, and thus contains billions of tons of potash. Our granite hills also contain large percentages of potash, all at present unavailable, as no cheap method of extracting the potash has yet been developed.

covering an immense area, are also rich in potash. In Utah and in the Goldfield district of Nevada important occurrences of alunite are reported, containing a possible important commercial source of potash.

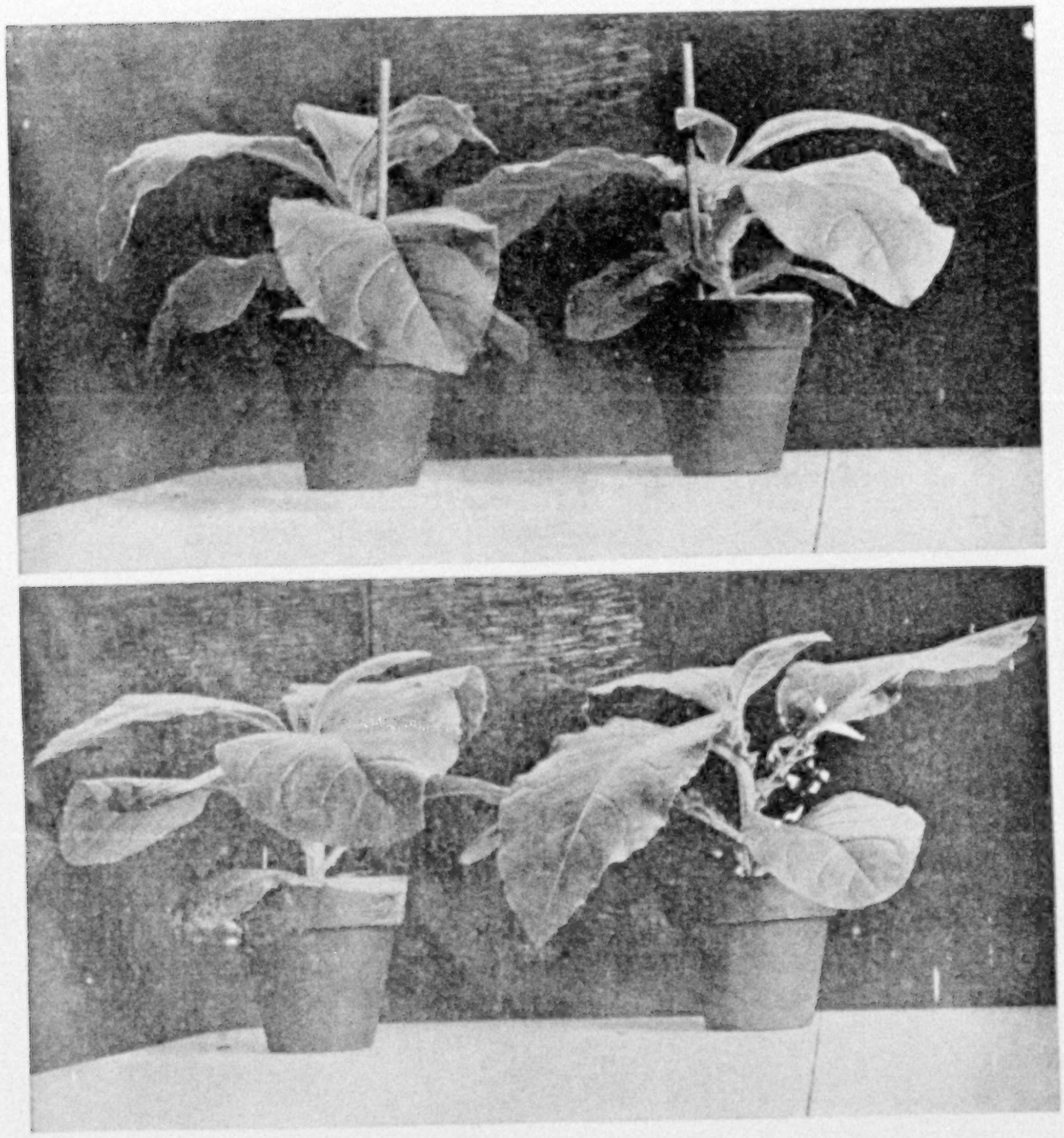
The supply of potash is, therefore, limitless. The trouble has been that inasmuch as the potash in these rocks is not soluble, as are the potash salts, it is not readily available as plant food. But it is not conceivable that it will long remain an unsolved problem to the chemist to extract potash from rocks on a commercial basis. Indeed it has been done in the laboratory again and again, and very recently several patents have been granted for processes devised for large-scale operations. One method only may be mentioned as showing that success is practically assured in unlocking the potash treasure vault and thus challenging German supremacy. Dr. Allerton S. Cushman, late of the Department of Agriculture, has perfected a process for treating ground feldspar with lime and other reacting substances and furnacing the mixture. He has already succeeded in thus rendering soluble 60 per cent of the potash contained in the feldspar, and expects to release the entire potash content when the process is put into commercial operation, using large rotary kilns, such as are employed in Portland cement manufacture. Working with 10 per cent potash feldspar, he will thus obtain a marketable product from three to four times as rich in potash as the ordinary "complete fertilizer" used by the farmer.

Methods of releasing the potash by electrical methods and others for recovering it as a by-product in the manufacture of cement and in various other ways are being worked out. In the grinding and converting of rock into cement, immense quantities of the potash of our hillsides are now wasted which might perhaps be saved. If science has already solved the intricate problem of converting the free nitrogen in the atmosphere into nitrate salts for fertilizer, the counterpart of Chilean nitrate of soda, it is not to be doubted that under the spur of necessity American chemists will get the potash out of rocks which are to be found at every hand. Moreover, there are vast fortunes in it for the men who develop practicable processes.

Doctor Cushman carried on, under the Department of Agriculture, a series of experiments, which indicate that the simple process of pulverizing feldspar makes it largely available as a plant food. He matured tobacco plants, which require large quantities of potash, using the ground feldspar as the sole potash fertilizer. If there were no better potash supply possible, ground feldspar or granite would undoubtedly be in general use as a fertilizer. It is probable that further experiments along these lines under various conditions will show a still greater and possible practical value for ground raw feldspar as a fertilizer.

Lime and water will have a dissolving effect on the potash in the fine particles of the rock, and it may be shown that if instead of spreading lime alone, as is common farm practice, considerable ground feldspar is added, the potash may be released year by year, just about as the plant needs it. In a similar way ground rock phosphate is now used to a considerable extent, although for years the statement was accepted that the phosphorus in rock phosphate was absolutely unavailable as a plant food unless the rock was treated with sulphuric acid. But it has been shown by several of the agricultural experiment stations that when applied to certain kinds of soils, heavy in humus, or when used in connection with barnyard manure, raw ground phosphate has a very great fertilizing value. With more extensive experiments similar good results may be expected in the use of potash-rich rocks.

In the agricultural appropriation law Congress also appropriated $12,500 to enable the Bureau of Soils to carry on potash investigations, and with the work vigorously pushed some definite results will in all probability be attained. This Bureau has a magnificent opportunity to determine and perfect a practicable method of extracting potash from rocks,



Photos by Allerton S. Cushman

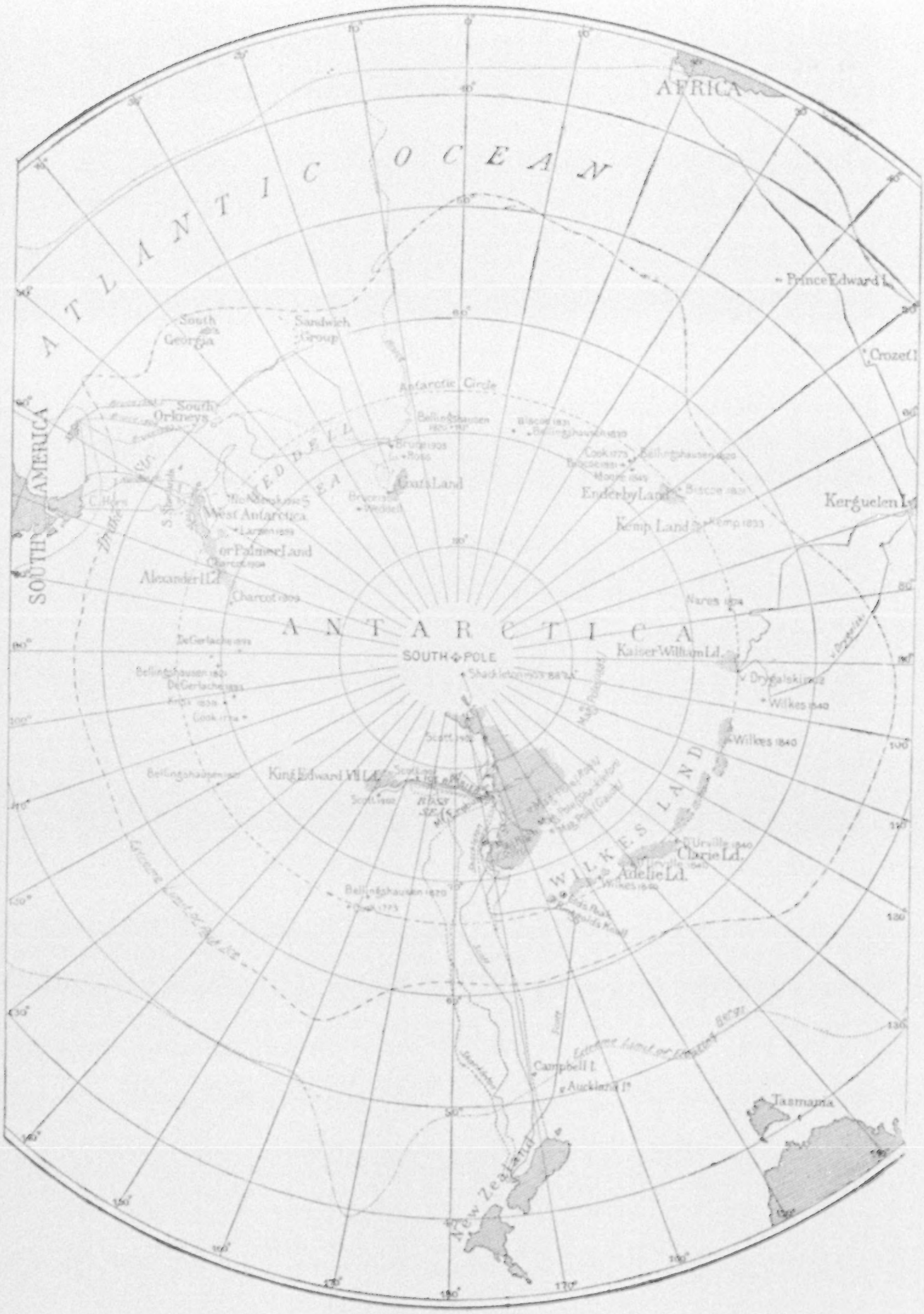
THE EFFECTIVENESS OF GROUND FELDSPAR AS A POTASH FERTILIZER

Comparison of tobacco seedlings, six weeks old, grown in sand mixed with ground feldspar, but containing no other potash (shown in upper photograph), with plants of same age grown in rich garden soil, which contains an adequate supply of soluble potash (shown in lower photograph). Dr. Cushman emphasizes the fact that this experiment was under most favorable green-house conditions and is not to be taken as applicable to field practice. The showing is, however, significant.

and thus forestall the possibility of an American potash monopoly.

While the outlook for the early development of an American potash supply, and consequent relief for the farmers, is, on the whole, most promising, it is to be regretted that Congress did not provide for more extensive work by the Government. A $200,000 appropriation would have enabled the Geological Survey, for instance, to distribute ten or a dozen parties with deep-drilling outfits over the western country and to find the nitrate and the potash beds at once, rather than to spread the effort over a period of years, and finally make the discovery after we have sent a quarter or a half a billion dollars to Germany and Chile. Nor would $50,000 have been too much to give the Secretary of Agriculture for exhaustive chemical investigations in potash and to continue and expand the promising experiments already begun by his department.

XUM



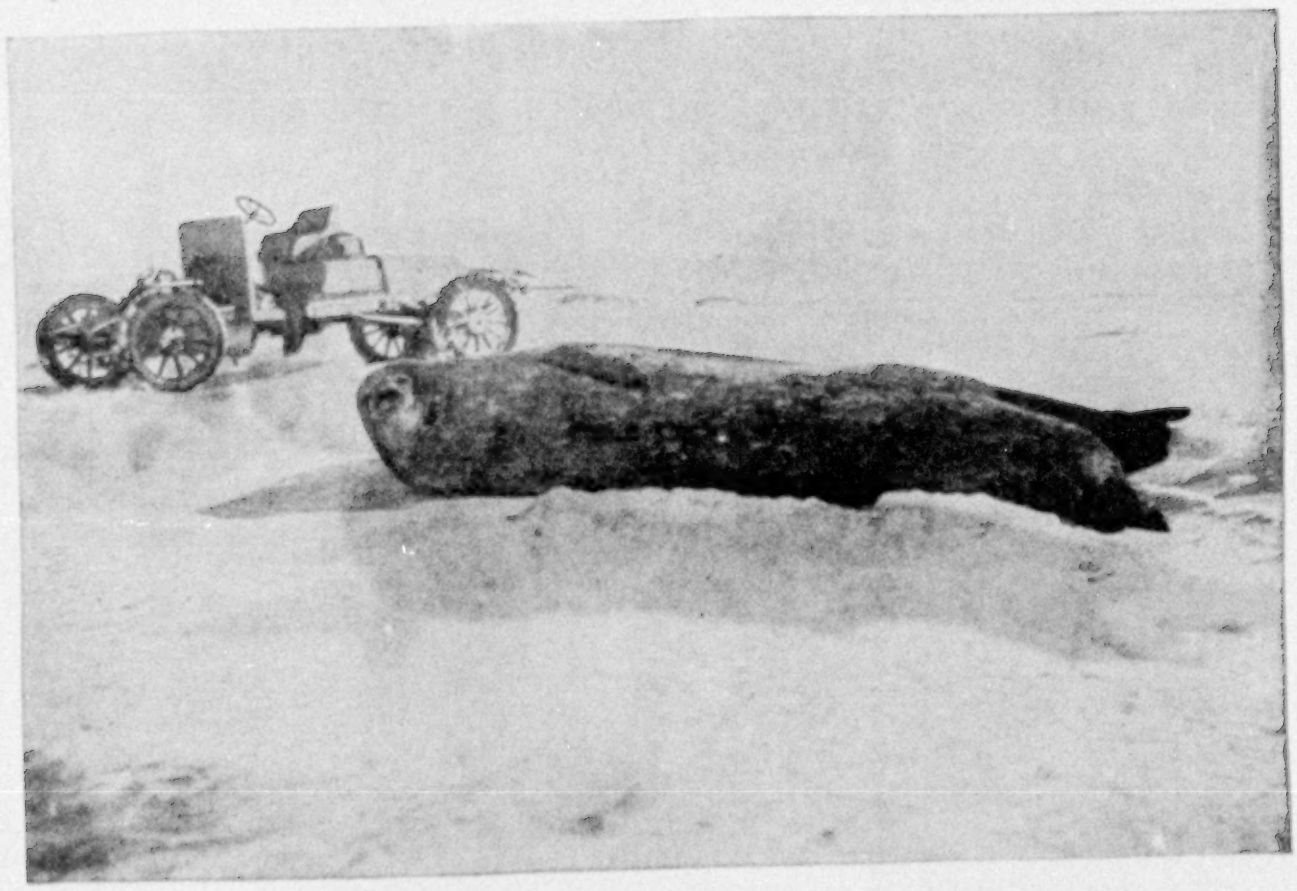
SKETCH MAP OF THE SOUTH POLAR REGIONS

SOUTH POLAR EXPLORATIONS

THREE expeditions, a British, a Japanese, and a Norwegian, will be struggling during the next 12 months to reach the South Pole. Unfortunately for scientific purposes, all three are endeavoring to gain the goal by practically the same route—from the vicinity of Mount Erebus over the great ice barrier, and then up over the great inland plateau. This is the route discovered by Scott and Shackleton, and over which the latter gained a point within 97 miles of the Pole in 1909 (see map on opposite page).

The British expedition is led by Capt. Robert F. Scott, of the Royal Navy, who directed the very successful British party of 1901-'04. Two years were spent in preparations for this last expedition, which left England in June, 1910. The party comprises 60 persons, including a large number of scientists and scientific assistants. They are provisioned for three years, and are using as their headquarters the same base that was occupied by Scott, 1901-'04, and by Shackleton, 1908-'09.

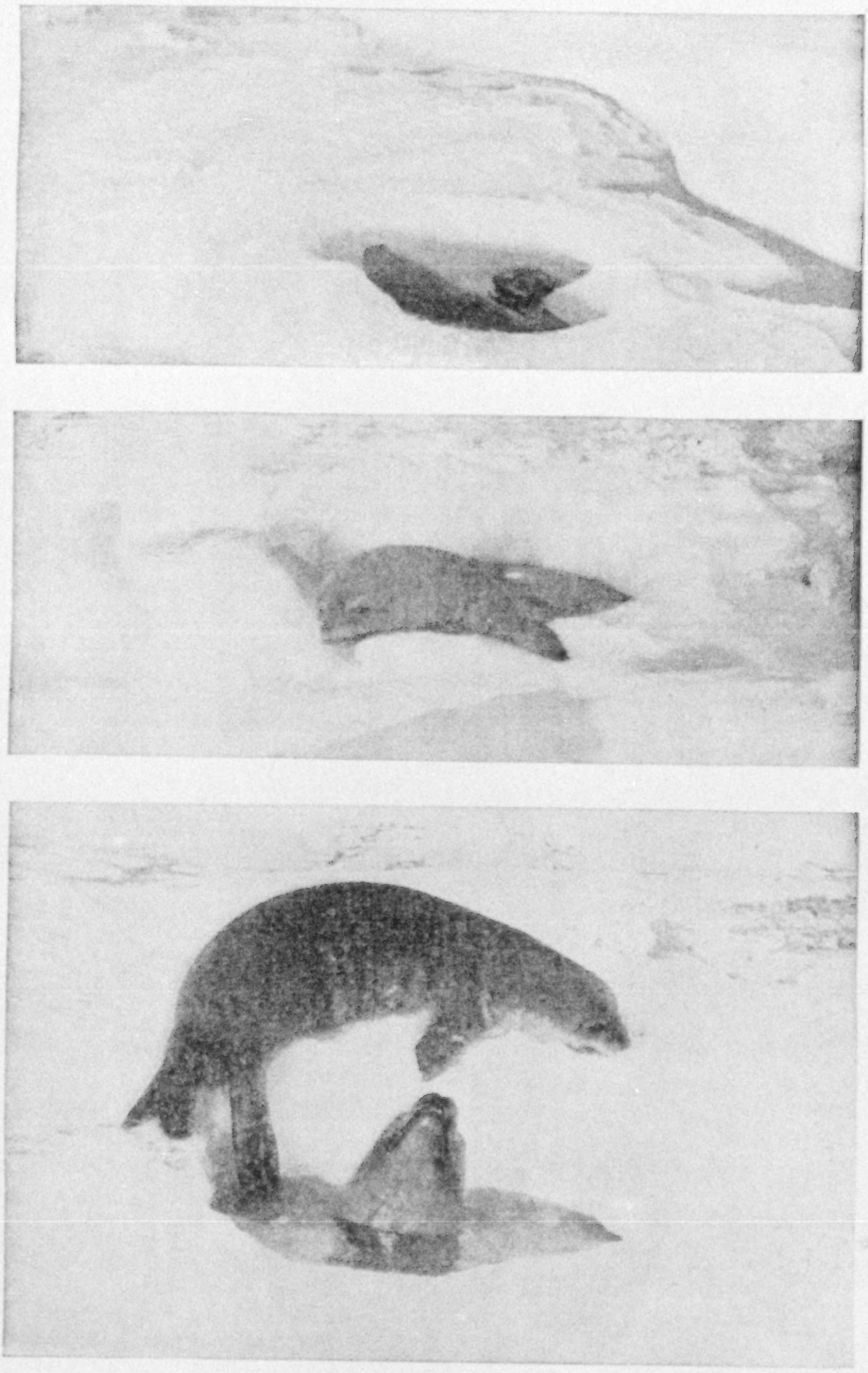
The *Terra Nova*, which has recently returned after landing Scott's sledge parties, reports that Amundsen, the leader of the Norwegian party, is also camped near by. Amundsen, it will be remembered, had been planning for several years to reach the North Pole by drifting across it. When he left Europe on the *Fram* in 1910, it was with the announced intention of proceeding around Cape Horn, thence up the Pacific through Bering Strait into the Arctic Ocean, where he was to allow his ship to be frozen in the ice. He was provisioned for five years, at the end of which time he expected to have drifted across the North Polar area and to be freed in the vicinity of Iceland or Norway. But from Madeira Amundsen cabled that he had altered his plans and would spend a year endeavoring to reach



SEAL SUCKLING YOUNG AND TAKING NO NOTICE OF THE MOTOR CAR

Photo taken on the Great Ice Barrier. From E. H. Shackleton, "The Heart of the Antarctic." J. B. Lippincott Co.

XUM



SEALS EMERGING FROM THE WATER AT THEIR BLOW-HOLES, NEAR MOUNT EREBUS
Photos from "The Heart of the Antarctic," by E. H. Shackleton. J. B. Lippincott Co.

the South Pole. It is presumed that he sought to land his party on King Edward VII Land, some distance from Scott's intended headquarters, but, like all explorers who have preceded him in this region, failed to find a satisfactory point for disembarking, and was compelled to continue along the great ice barrier to Mount Erebus.

The cabled advices have stated that Amundsen was to inaugurate his attack upon the Pole immediately, not waiting for the winter to pass before beginning his advance. From this we infer that he intends to take advantage of moonlight and advance depots of supplies up the route during the brighter periods of the polar night. Previous South Polar expeditions have confined their explorations almost entirely to daylight, though Peary's success in gaining high latitudes in the Arctics was largely due to the fact that he kept his sledging parties at work during the full moon.

The Japanese party is led by Lieutenant Shirase. Like Amundsen's, it is small in numbers. Shirase has not had the training in ice-work that Scott and Amundsen have experienced, and it is doubtful whether the heroic spirit of his party can prevail against the lack of equipment.

OUR DESERT PANORAMA

FOR the convenience of such readers of this Magazine as desire to frame the beautiful panorama, "The Hour of Prayer: In the Sahara Desert," which is published as a supplement to this number, a limited number of copies have been printed on very heavy art mat paper suitable for framing. The copies are unfolded, and may be obtained by applying to the office of the National Geographic Society and enclosing 50 cents for each copy desired.

The panorama is probably the most extraordinary desert scene that has ever been published. It represents a portion of the Sahara Desert not far from Biskra, and is typical of the vast billows of sand which cover many sections of the great desert.

As we look at the oceanic ridges in the picture we can easily understand the terrors of the desert storm, which has been described by many travelers.

We quote from Mary Somerville:

"The wind at the equinoxes rushes in a hurricane, driving the sand in clouds before it, producing the darkness of night at midday and overwhelming caravans of men and animals in common destruction. Then the sand is heaped up in waves ever varying with the blast; even the atmosphere is sand. The desolation of this dreary waste, boundless to the eye as the ocean, is terrific and sublime."

Duveyrier, in "Les Touareg du Nord," writes:

"The sand storms I have seen always took the form of vast clouds of a red color, appearing as if shot with fire, having a thickness of 50 to 60 meters and moving as rapidly as high winds, sometimes just above the surface of the ground, sometimes considerably higher, now dropping to the ground, now rising, but in any event moving through the atmosphere like a foreign and entirely isolated body.

"On one journey through the desert I had a near view of four such storms, and a fifth enveloped our entire caravan without our being able to escape it. . . .

"The storm on April 28 passed to the east of us like an immense reddish cloud and appeared like a vast conflagration. The likeness was so close that it might have deceived us if the cloud had not moved in such a way as to vary its height with respect to the horizon.

"It need hardly be said that while the sirocco lasts traveling is very painful, especially in the region of the dunes. Stories are told of entire caravans being engulfed by avalanches of sand. While

traversing the Erg during the hottest season of the year, when the wind was blowing constantly from the south, our caravan, worn out by the whirlwinds of sand which darkened the atmosphere and prevented the guides from leading the way, had to stop several times."

The most terrible form of the desert storm is the simoon, "the poison wind." As it approaches the observer its front extends at least from 5 to 20 miles, very much like the advancing front of a series of thunder-storms on a hot afternoon; the clouds of fine sand and dust that are carried up by the wind extend as a haze overspreading the sky; the heavier sands are also transported in large quantities, and as they fall are collected in mounds around every obstacle like the drifts of snow in winter. In the case of an extended simoon the finer sands are carried so high as to be drawn into the general circulation over Europe. Thus in the great storm of March 10-12, 1901, red and yellow sand and dust from the Sahara fell in nearly every portion of Germany, France, Austria, and Turkey, and southward over the Mediterranean, and was also reported in southern England for the first time on record.

In his explorations amid the sand dunes of Asia, Sven Hedin encountered many furious sand storms.*

"For it drove right into my face with terrific violence, smothering me with sand and fine reddish yellow powdery dust. I could not see a single glimpse of the caravan. It was like wading against running water or liquid mud, and despite my most desperate efforts I was unable to make headway. My previous footprints were entirely obliterated—obscured the instant I lifted my foot. . . .

"The camels knelt in a long row, with their necks stretched out flat on the ground in the direction in which the tempest was blowing. Close to the earth the wind had a velocity of 40½ miles an hour; but on the top of an adjacent mound, only 6 or 7 feet high, it was some 18 miles an hour more, or 58½ miles in all, and I was only able to keep my balance when I knelt. The storm came from the northeast, and its violence enabled me to form some idea of the inconceivable quantities of sand and dust which are transported by this mighty agent. When we stooped down we were well nigh choked by the swirling cloud, which careered along the ground like a cataract, making little eddies of dust as it swept on. Branches, tufts of grass, grains of sand as big as peas were whirled into our faces with stinging force. . . .

"Only those who have been out in such a storm can form any conception of what it is like. You get bewildered and want to keep going, without knowing where. Your sense of locality is paralyzed, and although you think you are going in a straight line, you are in reality describing a circle. It is a kind of desert storm sickness, more nearly resembling the panic which seizes a person on the edge of a precipice than seasickness or mountain-sickness, because it affects the brain."

* From "Central Asia and Tibet," Sven Hedin. Charles Scribner's Sons.

MAP OF MEXICO.

A LARGE map of Mexico, 18 by 25 inches, and in colors, will be published as a supplement to the next number of the NATIONAL GEOGRAPHIC MAGAZINE. The map gives the railway lines, names of towns and villages, and all the latest geographical information. The elevations of the different parts of Mexico are shown by gradations of color.

The same number will contain two notable articles on Mexico, "Our Neighbor, Mexico," by Mr. John Birkinbine, President of Franklin Institute, Philadelphia, and formerly President of the American Institute of Mining Engineers; and "Lower California," by Mr. E. W. Nelson, of the United States Biological Survey.

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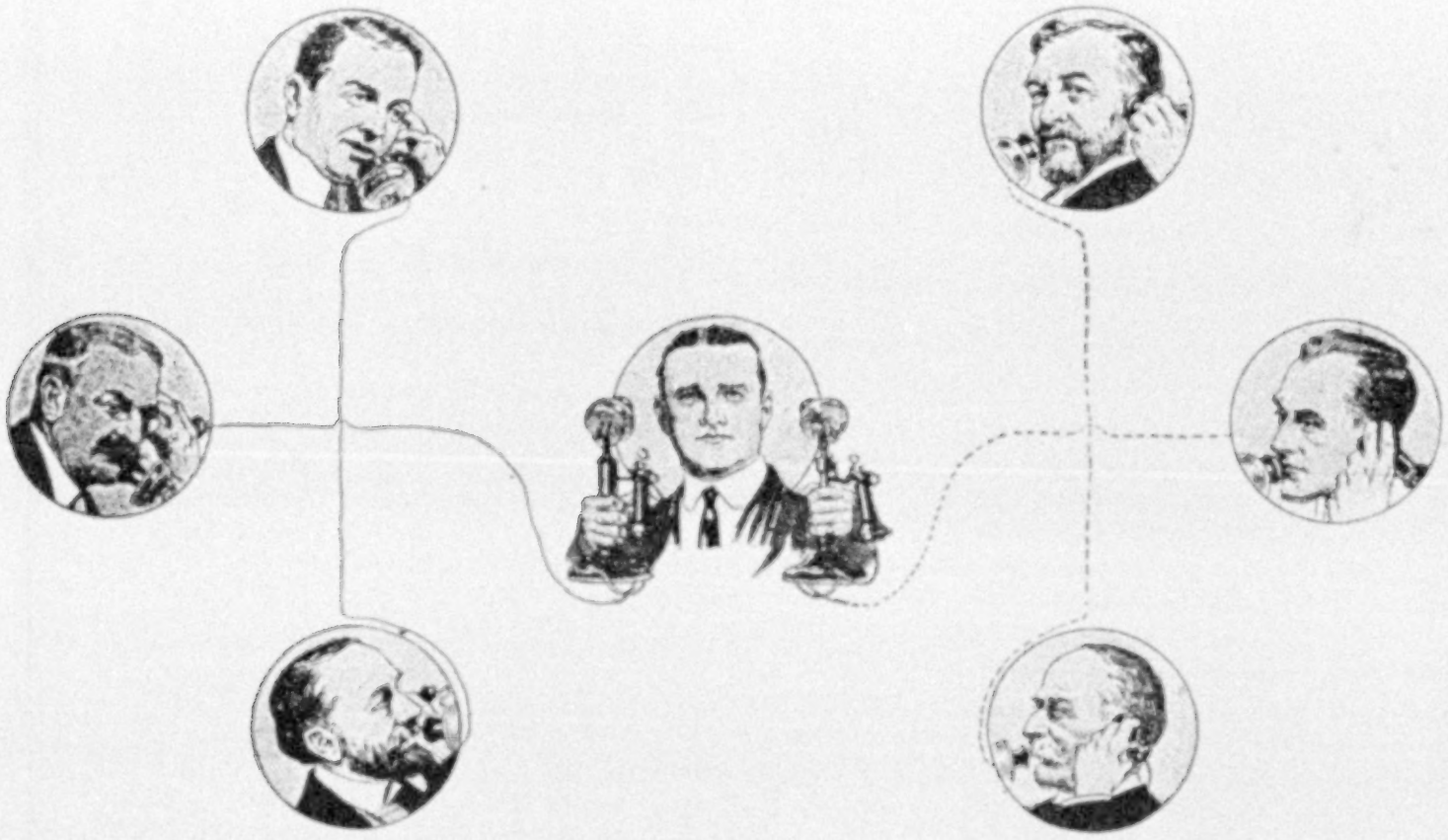

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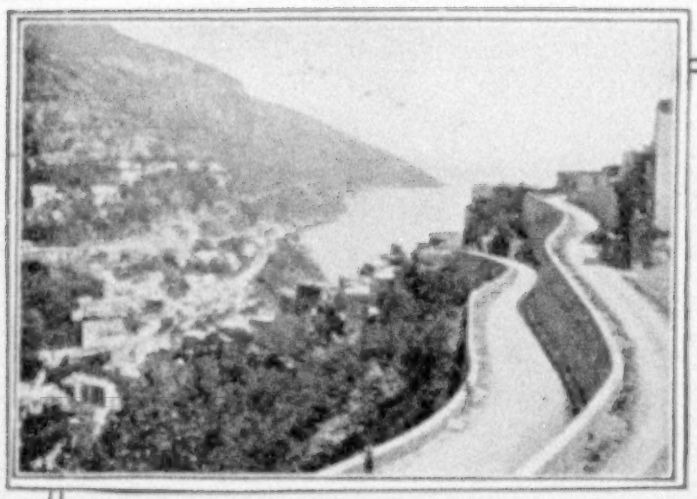

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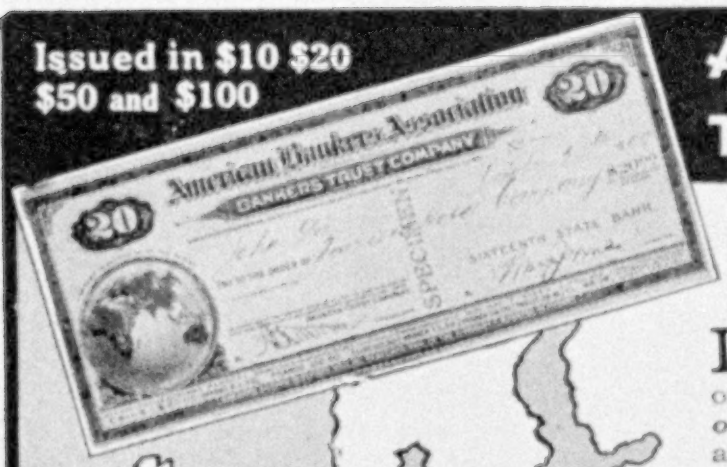

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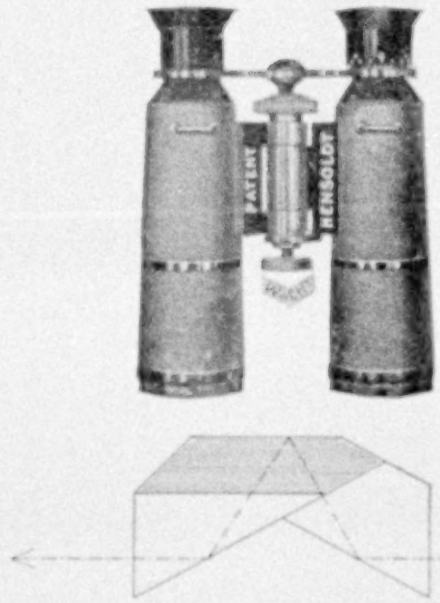

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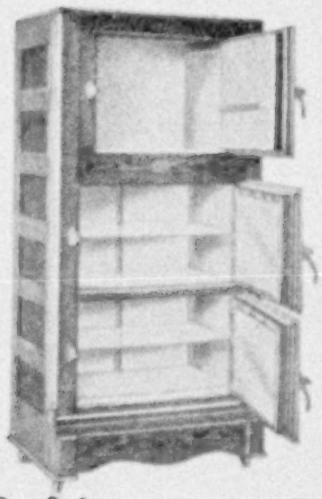

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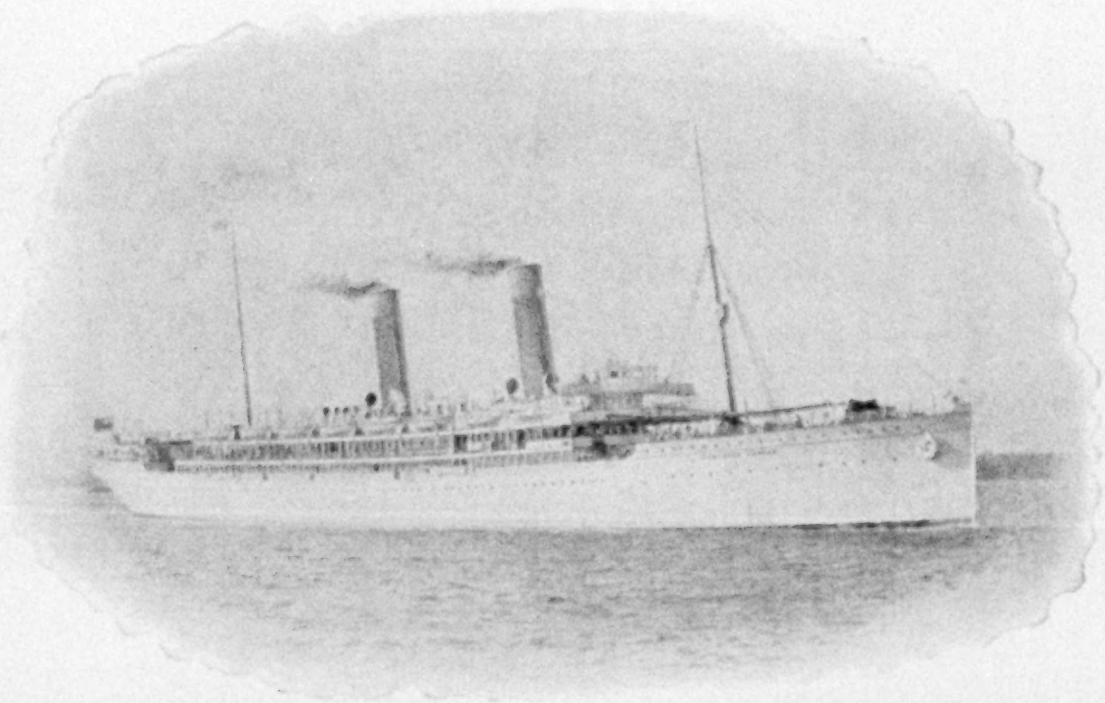

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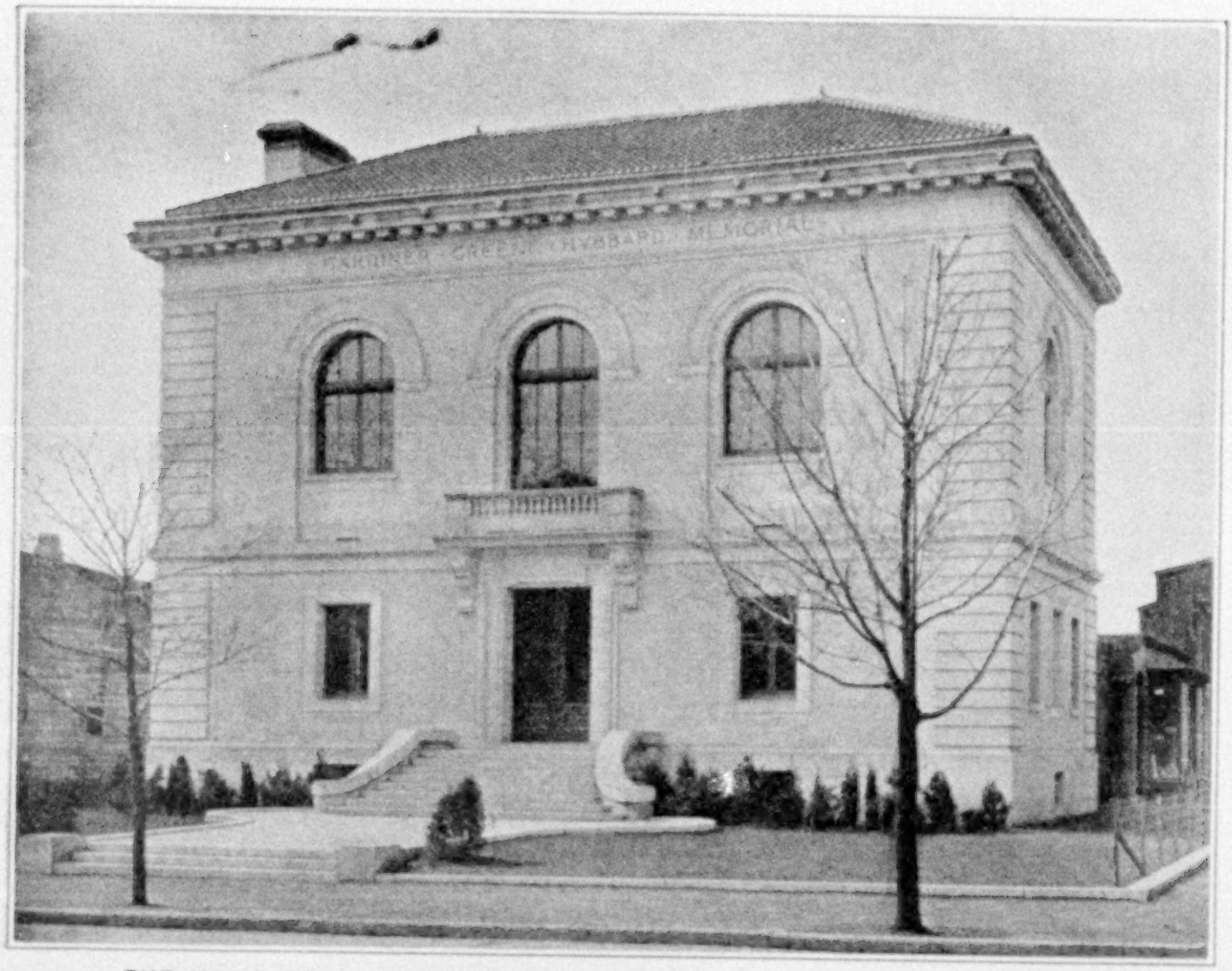

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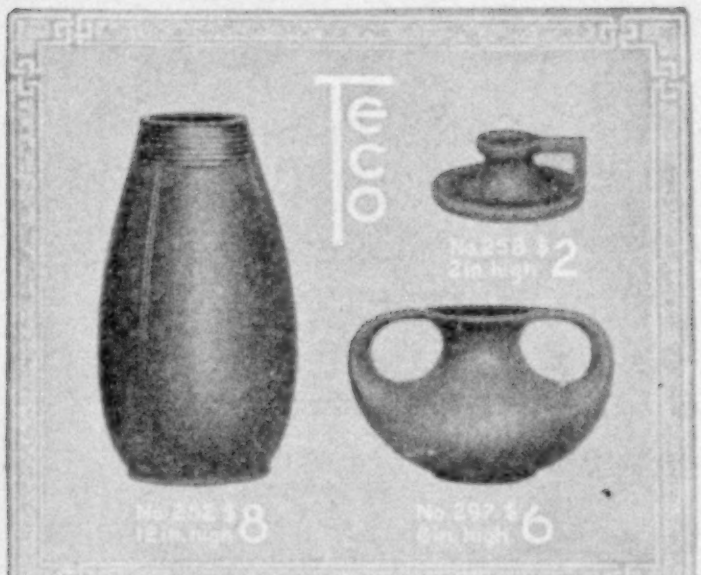

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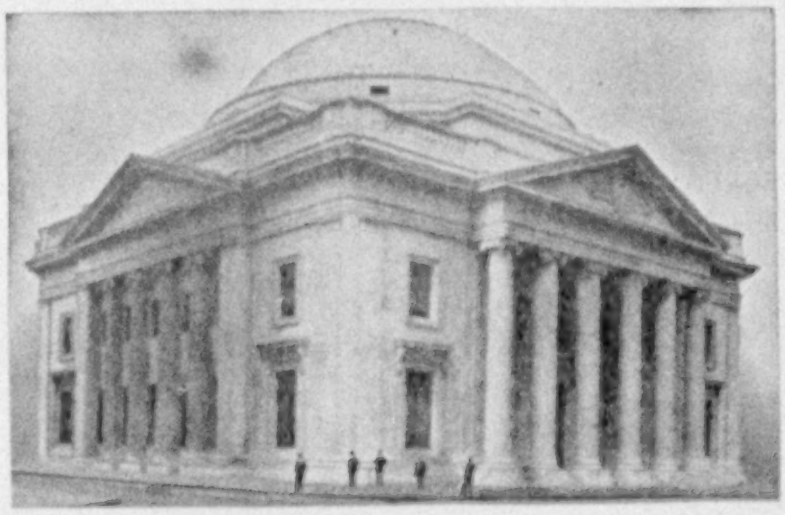

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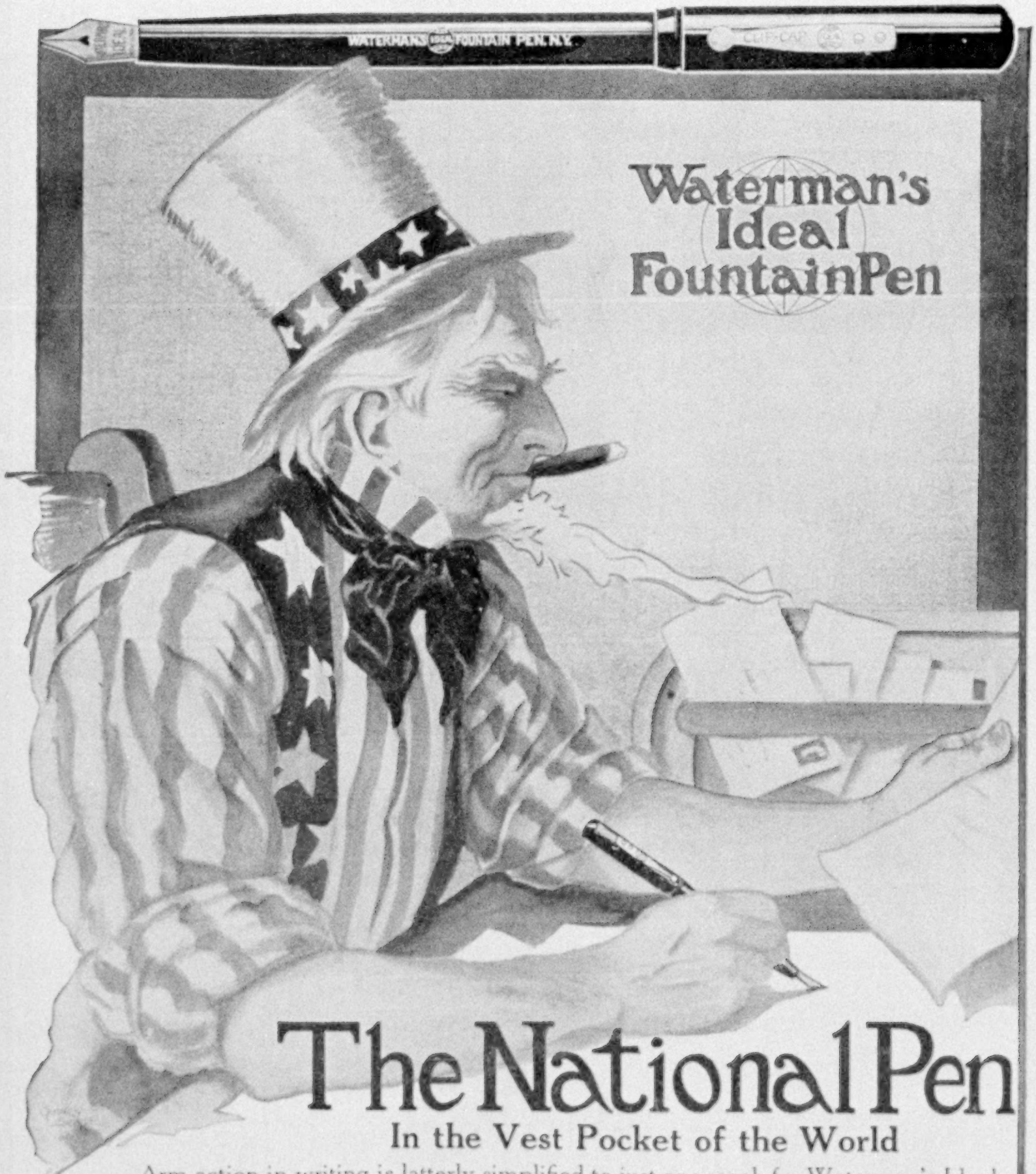

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